an atlas of

EMBRYOLOGY

Number of somites	Stage*	Incubation time in hours according to:— Duval	Huettner	Patten	Lillie	Primitive streak	Nervous system	Mesoderm, somites and kidney	Vascular system	Anterior intestinal portal
0	4	20	17–18	18	18–19	Maximal length, 2.2 mm. i.e., 0.7 of area pellucida. Groove, pit and node present.		Shield shaped sheet of mesoderm spreads out laterally from the primitive streak.		
0	5 & 6	21	19	20	19–22	Begins to decrease in length, 1.9 mm. Notochord grows forward from node.	Neural plate and neural folds visible.	Lateral horns of mesoderm grow forward. The first somite may appear simultaneously with the formation of the head fold (stage 7).	Mesenchyme cells form isolated blood islands in extra-embryonic mesoderm.	First seen to be present.
3	8–	22	23	23	25–28	Reduced to a length of 1.5 mm.	Neural folds meet in brain region but do not fuse.	Lateral horns grow round the mesodermless proamnion. Segmented somites joined to lateral plate mesoderm by intermediate mesoderm (nephrotome). A cavity, the myocoel, appears in somites.	The blood islands begin to unite and the first blood corpuscles are produced within the resulting tubes.	Moves back as the foregut elongates.
5	8+	23–25	25	25–26	27–30	1.2 mm. long.	Fusion of folds begins in brain region; further back neural folds meet but they splay out over the somites.	The cells of the somites become radially arranged about the myocoel cavities; cavity reduced by a central core of cells. Lateral horns meet anteriorly.	The embryo becomes linked to the blood island system by vitelline veins. Paired primordia of the heart develop together with ventral and dorsal aortae.	Lies posterior to the heart primordia.
10	10	29–30	30	30–31	33–38	0.6 mm. long.	Except for anterior neuropore, fusion of folds is completed in the brain region. Three primary brain vesicles visible.	The intermediate mesoderm begins to separate off dorsally. The pronephric tubules develop from this material between somites six and ten. The first somite begins to disappear.	The heart primordia fuse to form a tubular heart which bends slightly to the right of the embryo. Faint and sporadic pulsation of the heart occurs.	May reach the first somite.
13	11	33–34	33	33–34	40–45	0.4 mm. long.	Five brain vesicles can be seen. Anterior neuropore closes. The neural folds fuse beyond the thirteenth somite.	The dorso-lateral buds differentiate into pronephric tubules and the pronephric duct forms by fusion of material from the tubules. First signs of Wolffian duct.	The heart becomes distinctly displaced to the right. The rate and amplitude of the heart beats increase. A network of blood vessels established in area vasculosa.	Reaches the second somite.
17	12+	37–41	37	38–40	46–50	0.2 mm. long.	Fore brain at an angle to hind brain due to flexure. A shallow infundibulum is present.	Connection between somites and nephrotomes is lost. The mesonephros develops along with pronephros below the somites. Wolffian duct extends from tenth to fifteenth somite. Differentiation begins in anterior somites.	The heart is beating efficiently by this stage and blood circulates. The heart is S-shaped. The first aortic arch begins to develop. The dorsal aortae fuse between somites three and four. The vitelline artery can be seen between somites sixteen and seventeen.	Reaches the third somite.
21	14+	43–46	43	44–48	48–52	No longer distinguishable. contributes material to tail bud.	Fore brain at right angles to hind brain. Fore brain enlarges in telencephalon region.	Pronephros begins to disappear anterior to the eleventh somite. In the anterior somites a distinct dermatome can be seen and cells migrate from the somites and neural crests to form the sclerotomes round the notochord.	The atrium begins to divide into right and left auricles. The first aortic arch is established and the second begins to form. Fusion of dorsal aortae may reach somite eight. The vitelline artery is distinct between somites 17–19.	Reaches the fourth somite.
24	15	44–46	48	48–50	50–55		The telencephalon becomes distinct from the diencephalon. Rathke's pocket grows under the infundibulum.	The posterior somites remain undifferentiated; anteriorly somites differentiate into dermatome, myotome and sclerotome. There are eleven pairs of mesonephric tubules between somite five and sixteen.	Besides the two auricles heart has distinct ventricle and conus arteriosus. Two aortic arches present. Dorsal aortae fuse as far back as somite twelve. The vitelline arteries lie between somites eighteen and twenty.	Is in the region of somites five to six.
27	16	48	50–52	50–55	51–56		Telencephalon and diencephalon become separated by the velum transversum. A distinct isthmus can be seen between the mesencephalon and metencephalon.	Differentiation into dermatome, myotome and sclerotome reaches somite twenty. Wolffian duct and mesonephric tubules seen in trunk sections.	The third aortic arch appears. The dorsal aortae fuse between somites four and fourteen. The vitelline artery lies between somites 19 and 21. Vitelline veins join to form ductus venosus which opens into sinus venosus.	Lies between somites seven and ten.
30	17	52	58–60	55–60	52–64		The isthmus deepens. Paired telencephalic vesicles develop. Roof of hind brain becomes very thin in myelencephalon region. Brain bent double by now.	Differentiation reaches the twenty-fifth somite. Wolffian duct grows back towards cloaca. Glomeruli can be seen in mesonephric tubules.	There are three complete aortic arches and the fourth begins to develop. The first pair of aortic arches may begin to atrophy at this stage. Dorsal aortae fused up to somite 16. Vitelline artery between somites 20 and 22.	Has moved back to lie between somites ten and twelve.
36	18+	68–72	72	72	72		The cerebral hemispheres develop from the telencephalic vesicles. The infundibulum joins with Rathke's pocket to form the pituitary.	Differentiation reaches the thirtieth somite. Wolffian duct reaches cloaca but may not fuse with it until later.	The first pair of aortic arches continue to atrophy as the fourth pair develop. Dorsal aortae fused as far back as somites 17–20. Vitelline artery is in region of somites 21–22.	Between somites thirteen and fourteen.

* Hamilton & Hamburger

Alimentary system	Eyes	Ears	Flexure	Torsion			
Foregut 0.15 mm. long.							
Foregut 0.3 to 0.4 mm. long.							
Foregut 0.5 to 0.8 mm. long.	*Prim[illegible]*						
Foregut about 1.0 mm. long.	*O[illegible]*						
Foregut is about 1.3 mm. long.	*D[illegible]*				*d*		
The foregut is 1.5 mm. long and there are indications of the first pair of visceral clefts.	*Ti[illegible]*				*d*		*The remains of the primitive streak begin contributing material posteriorly to the tail bud.*
The first pair of visceral clefts are distinct and the second pair begin to form.	*The lens rudiments invaginate to form lens vesicles. The optic vesicles invaginate to form optic cups*	*The mouth of each auditory pit begins to constrict and auditory vesicles form.*	*Cranial flexure, i.e. angle between fore- and hind-brain, is 90°. Cervical flexure begins in hind-brain region and trunk flexure can also be seen.*	*The head is fully turned to the left. The first five to seven somites also exhibit torsion.*	*The hind brain and first few somites are covered by the amnion. Tail folds may begin to develop.*		*There is a distinct tail bud.*
The first and second visceral clefts are clearly visible; the third pair begin to develop. The hind gut appears.	*The mouth of the lens vesicle begins to close.*	*The mouth of the auditory vesicle is reduced to a small aperture.*	*Cranial flexure causes the fore-brain to be directed backwards close to the heart. Cervical flexure becomes a broad curve.*	*Torsion is apparent in somites eight to ten.*	*The sero-amniotic connection is somewhat attenuated. The amnion covers somites six to thirteen. Tail fold appears.*		*The tail bud begins to develop posterior to the hind gut.*
The first, second and third visceral clefts are present. The liver bud appears as do the tail gut and anal plate.	*The lens becomes cut off from the ectoderm. The optic cups are almost closed. The retina distinct. The eye is still anterior to the ear.*	*The auditory vesicle is connected to the small ectodermal aperture by the ductus endolymphaticus.*	*Cranial flexure is at its maximum. Cervical flexure increases. Trunk flexure is noticeable in the region of somites ten to twelve.*	*Torsion extends to somites eleven, twelve and thirteen or even further.*	*The head fold grows back and may lie anywhere between somites ten and eighteen. The tail fold begins to grow forward.*		*The tail bud can be seen projecting behind the hind gut. The limb buds appear as low swellings.*
The fourth pair of visceral clefts develop. The liver bulge is now conspicuous. Tail gut extends further into tail. Cloaca begins to form.	*The optic cup closes. The eyes now lie posterior to the ears.*	*The aperture closes.*	*Cranial flexure remains unchanged. Cervical flexure is about 100°. Trunk flexure develops into a broad curve. Caudal flexure begins.*	*Torsion as far back as somites fifteen to nineteen.*	*The head fold has extended to the region between somites sixteen to twenty-four. The tail fold has grown forward aver somites 29–30.*	*Begins as an outgrowth of the hind gut in the cloacal region.*	*The tail bud begins to curve forward. The fore limb bud lies between somites 17–19 and the hind limb bud between somites 26–30.*
Four pairs of visceral clefts. The tail gut begins to degenerate. The anterior and posterior intestinal portals approach each other, leaving an open intestinal umbilicus of 3 mm. Lung buds develop.	*The eyes, due to flexure, lie well posterior to the ears.*	*The auditory vesicle is pear-shaped with a narrow ductus endolymphaticus.*	*Caudal flexure causes tail to be at an angle of 90° to the body.*	*The whole posterior region exhibits some degree of torsion.*	*The head and tail folds meet or leave a small oval aperture over somites 26–28.*	*Allantoic stalk and vesicle. The vesicle enlarges after 72 hours.*	*Limb buds are now quite conspicuous and begin to exhibit nipple-shaped apices The hind limb bud extends to somite 32.*

An Atlas of Embryology

by

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Preface

This book consists of photomicrographs of sectioned and entire embryos of frog and chick, with large detailed drawings to correspond.

Descriptive embryology is still recognised as a necessary and valuable part of courses in zoology and biology leading to the General Certificate of Education at Advanced Level, and to first degrees. As teachers and examiners we have become aware of the difficulties experienced by students in interpreting the embryological structures seen under the microscope. The present book is intended to help overcome these difficulties, while at the same time summarising the descriptive embryology of frog and chick in sufficient detail for degree level. Care has been taken to label fully, and to make the drawings and photographs large enough for clearness.

It has become apparent that the embryology slides in general use are not of very high quality. For this reason, little attempt was made to obtain slides of better quality, but to use those normally confronting the student – in this way we hope to have improved the chances of artifacts being recognised as such. A large number of slides was looked through, but in the end we confined ourselves to a relatively small number of the more typical specimens. By doing this we were able to produce a book inexpensive enough for wide general use.

Each slide was photographed through the microscope, with special attention being paid to securing a flat field and good depth of focus – especially difficult with these rather large specimens. Not all the slides selected for inclusion were of a quality desirable for photomicrography, as will be obvious from the photomicrographs themselves; but we feel that this need be no great drawback, since students are often required to interpret these poorer-quality slides.

Each drawing was made completely independently of the photograph, directly from the slide. An accurate outline was obtained by microprojection, with the emphasis on line work, as it should be in students' drawings. Where it made for greater clarity, the drawing was diagrammatised, as in the case of some of the embryonic membranes. Later the drawing was compared with the photograph, and dotting was added where it seemed desirable for greater clarity. It will be seen that more detail appears in many of the drawings than in the corresponding photographs. This detail is obtainable only by the proper use of the fine focusing of the microscope at increased magnification, and should serve as a salutary reminder to the student that it is necessary for *him* to do the same to interpret *his* slides!

Much care and effort has been expended on the labelling of the drawings, and all the usual texts have been consulted. Even so, it was often necessary to have recourse to serial sections, where these were available. In many cases, none were, and so some errors are likely to remain, even though we were fortunate to have the fullest co-operation of Dr Ruth Bellairs, of University College, London, in checking the work. We are most grateful to Dr Bellairs for her great help; any errors remaining are, of course, the entire responsibility of the authors.

It would not have been possible to have produced this work from the slides already in our possession. For their kindness in making available extra material, we are deeply indebted to the following: Mr Charles Biddolph, Mr C. V. Brewer, Dr Ben Dawes, Mrs J. Froud, Mr George Gardener, Mr A. T. Green, Mr C. Heather, Dr Brian Lofts, Mr C. T. Pugsley, Mr A. R. Tindall, Mr H. Whate, and the Zoology Department of Wye College. To

Mr George Gardener we owe an additional debt for his early criticism and encouragement. We were likewise fortunate in our lettering artist, Mr Alan Plummer, who co-operated in a most wholehearted manner; and also in our Publishers – in Mr Alan Hill and Mr Hamish MacGibbon we found a most sympathetic support and facilitation of our aims. Last, but very definitely not least, we must thank our wives very sincerely indeed for their help and encouragement, and for their stoicism when surrounded for weeks on end by all the impedimenta of drawing and photomicrography.

September 1962

W.H.F.
B.B.

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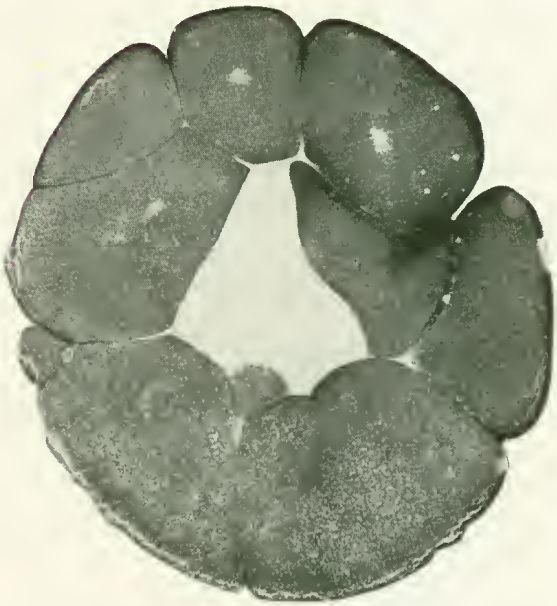
67 Chick: 36-somite stage, H.L.S.

A reference table of chick development is printed on the end-papers

1. **Frog:** cleavage, 2-cell stage, V.S. *mag. 50* ×

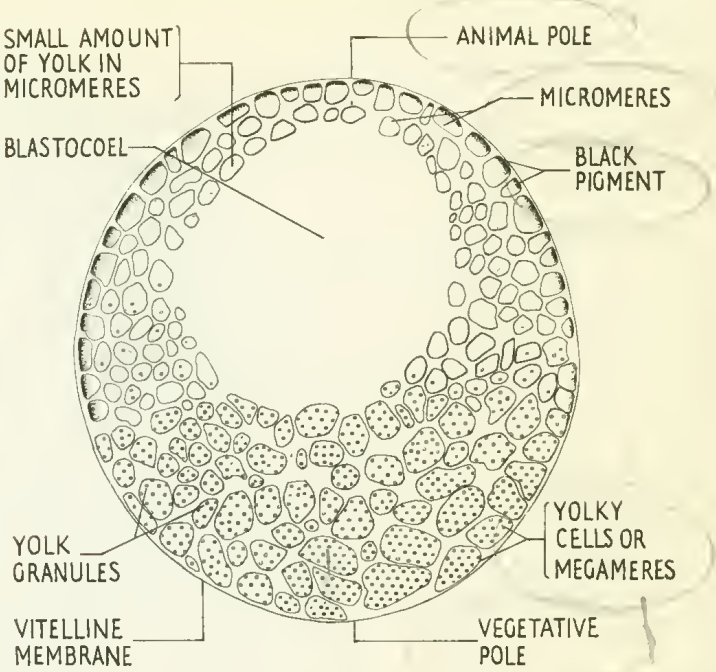
2. **Frog:** cleavage furrows, V.S. *mag. 50* ×

3. **Frog:** cleavage, 16-cell stage, V.S. *mag. 50* ×



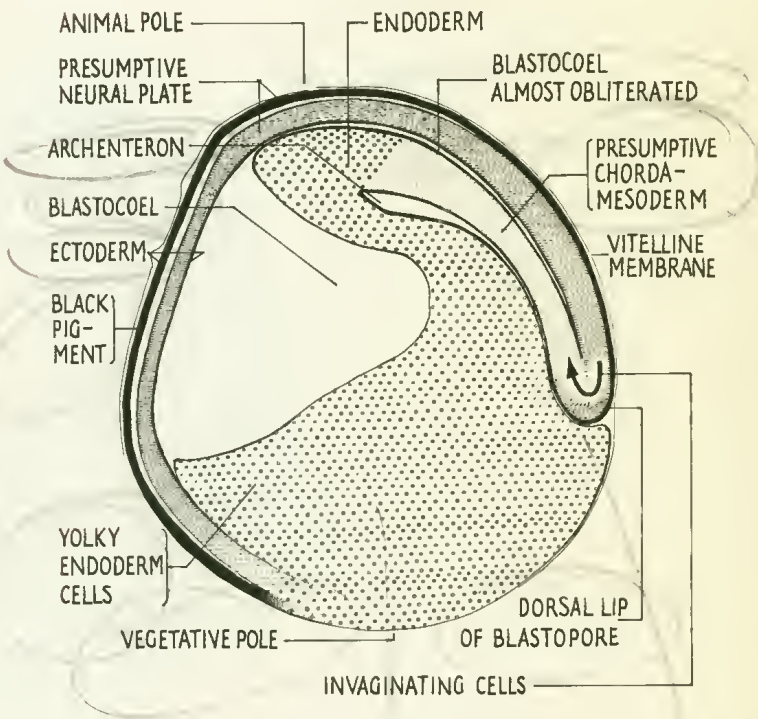
4. **Frog:** cleavage, 24-cell stage, V.S. *mag. 50* ×

5. **Frog:** cleavage, blastula, V.S. *mag. 45* ×



Drawing of specimen 5

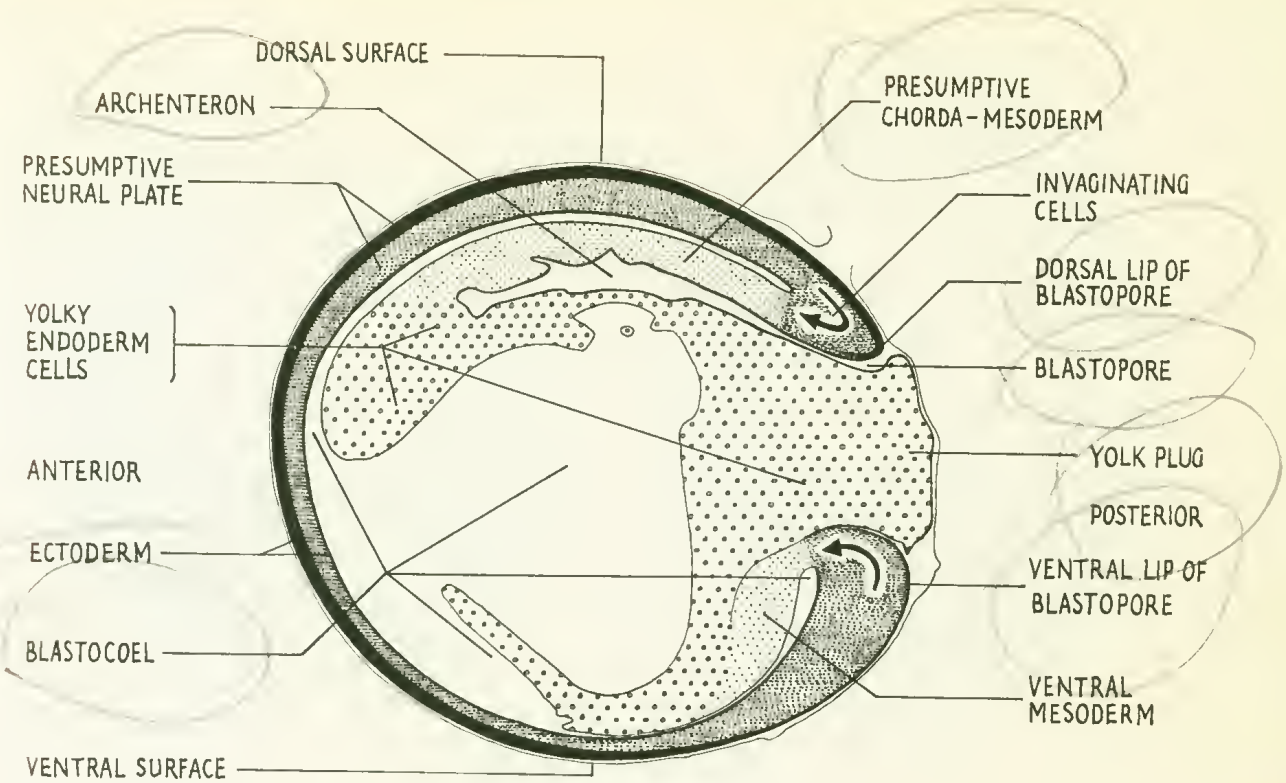
6. **Frog:** early gastrula (dorsal lip), V.S. *mag. 40* ×



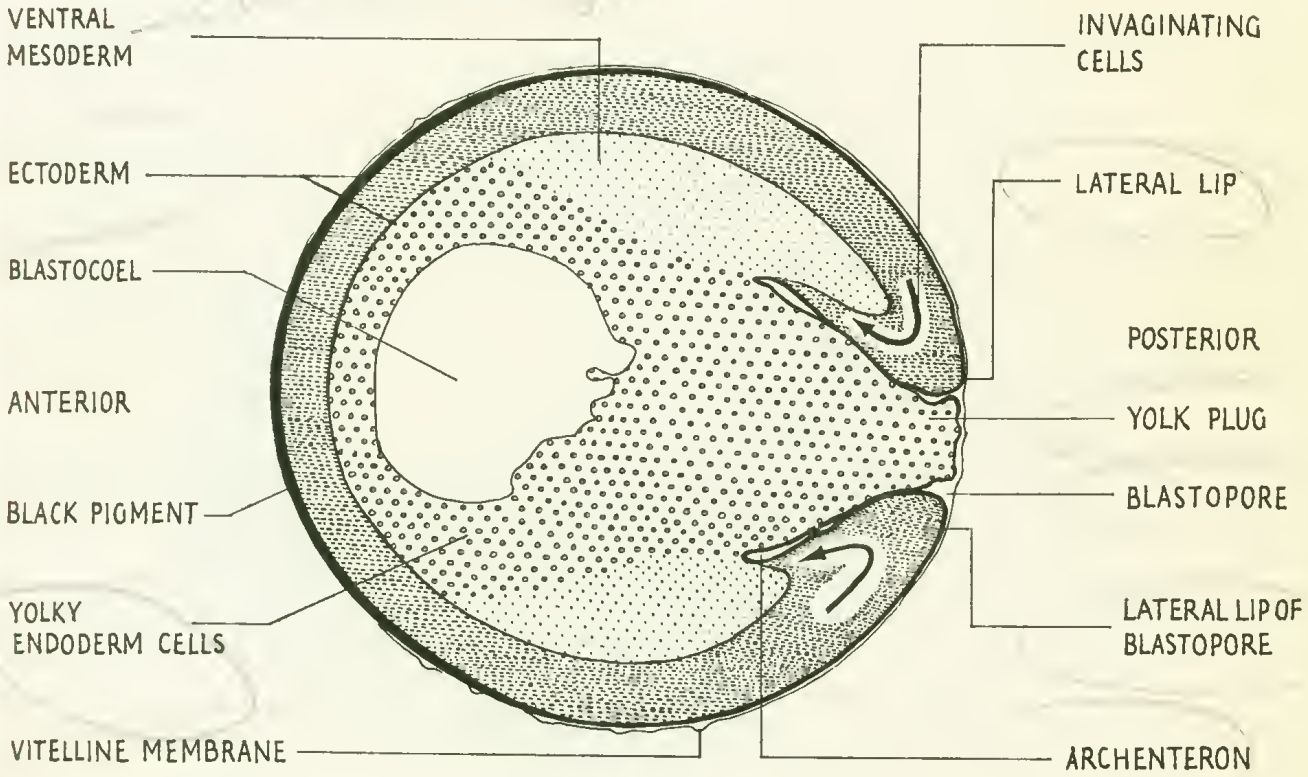
Drawing of specimen 6

7. **Frog:** later gastrula (yolk plug), V.S. *mag.* 60×

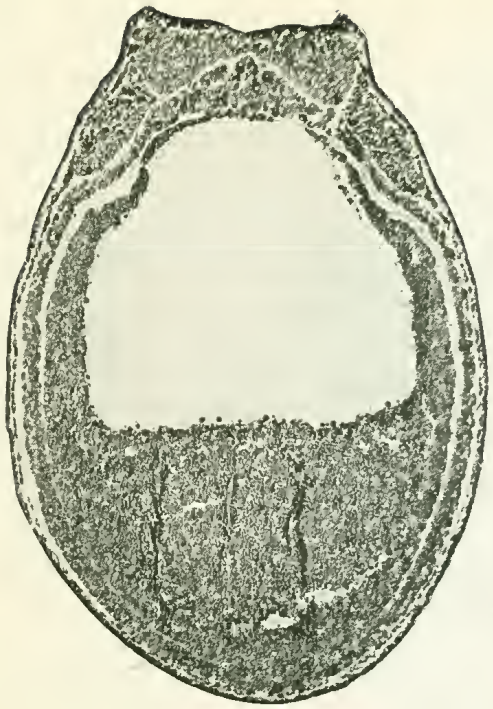
8. **Frog:** later gastrula (yolk plug, H.S. *mag*). 60×



Drawing of specimen 7



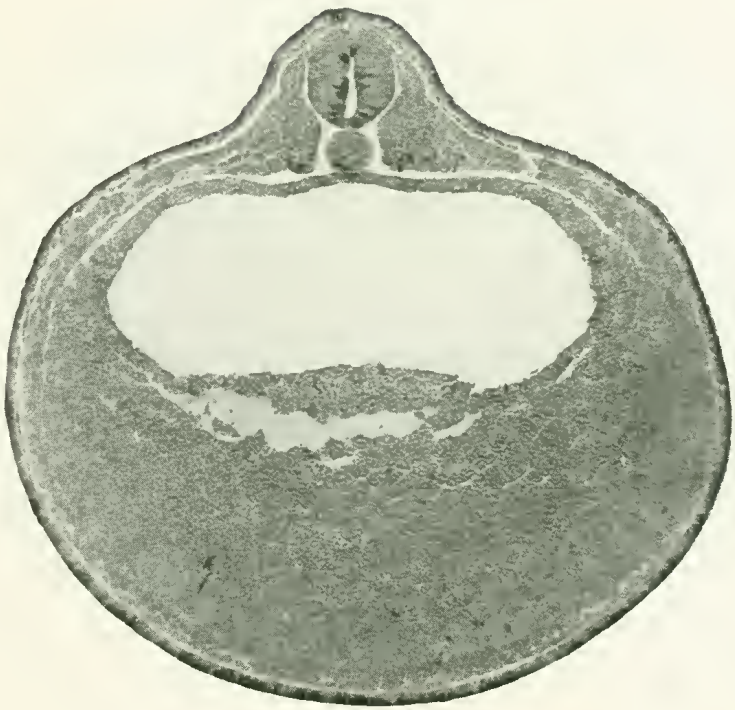
Drawing of specimen 8

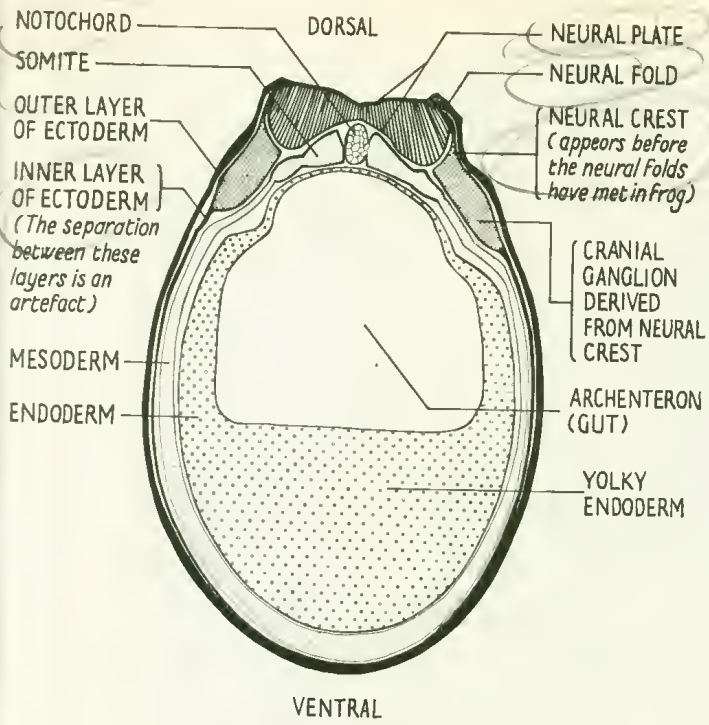


9. **Frog:** neural plate stage, T.S. *mag.* 35×

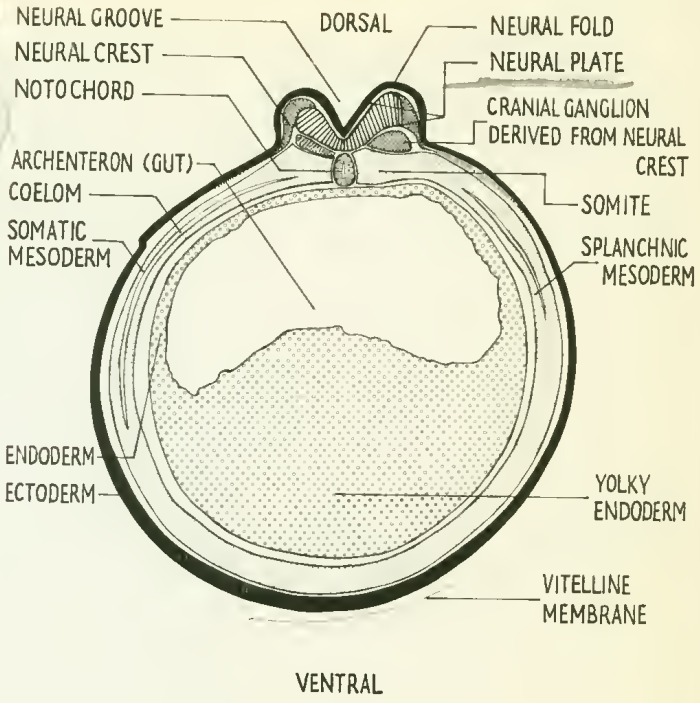
10. **Frog:** neural fold stage, T.S. *mag.* 35×

11. **Frog:** neural tube stage, T.S. *mag.* 42×

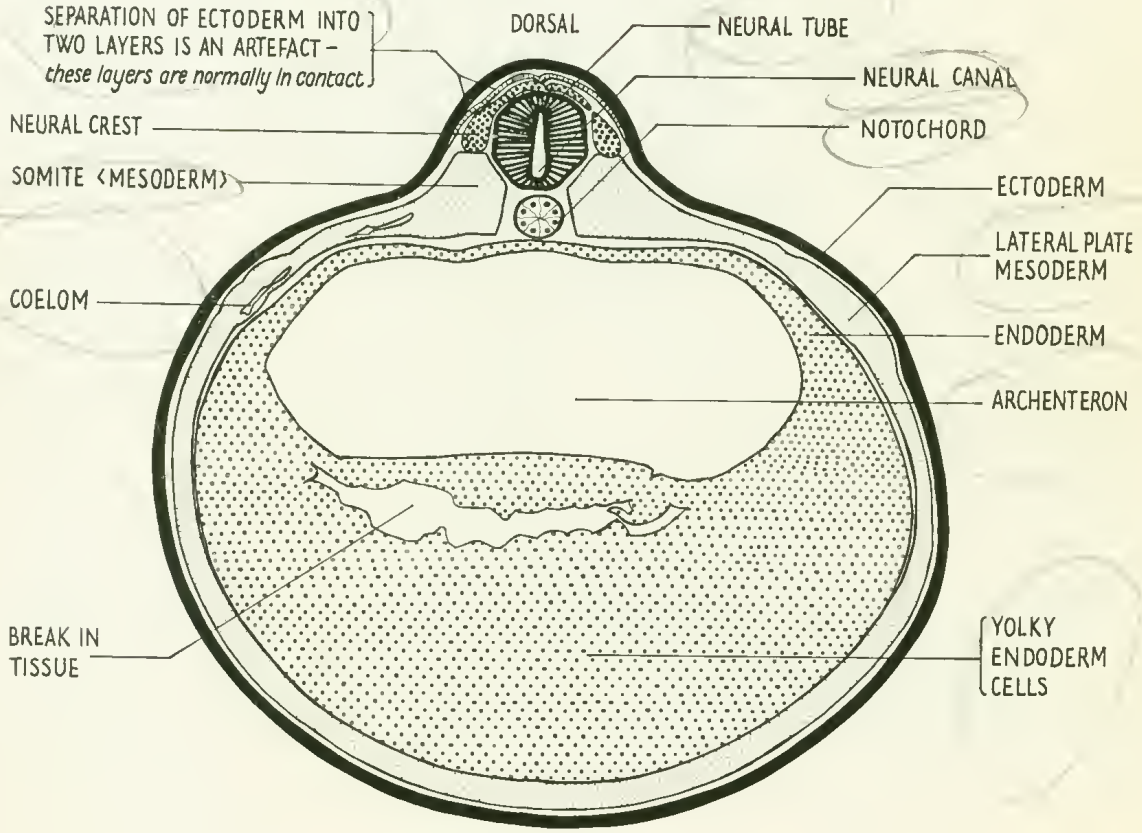




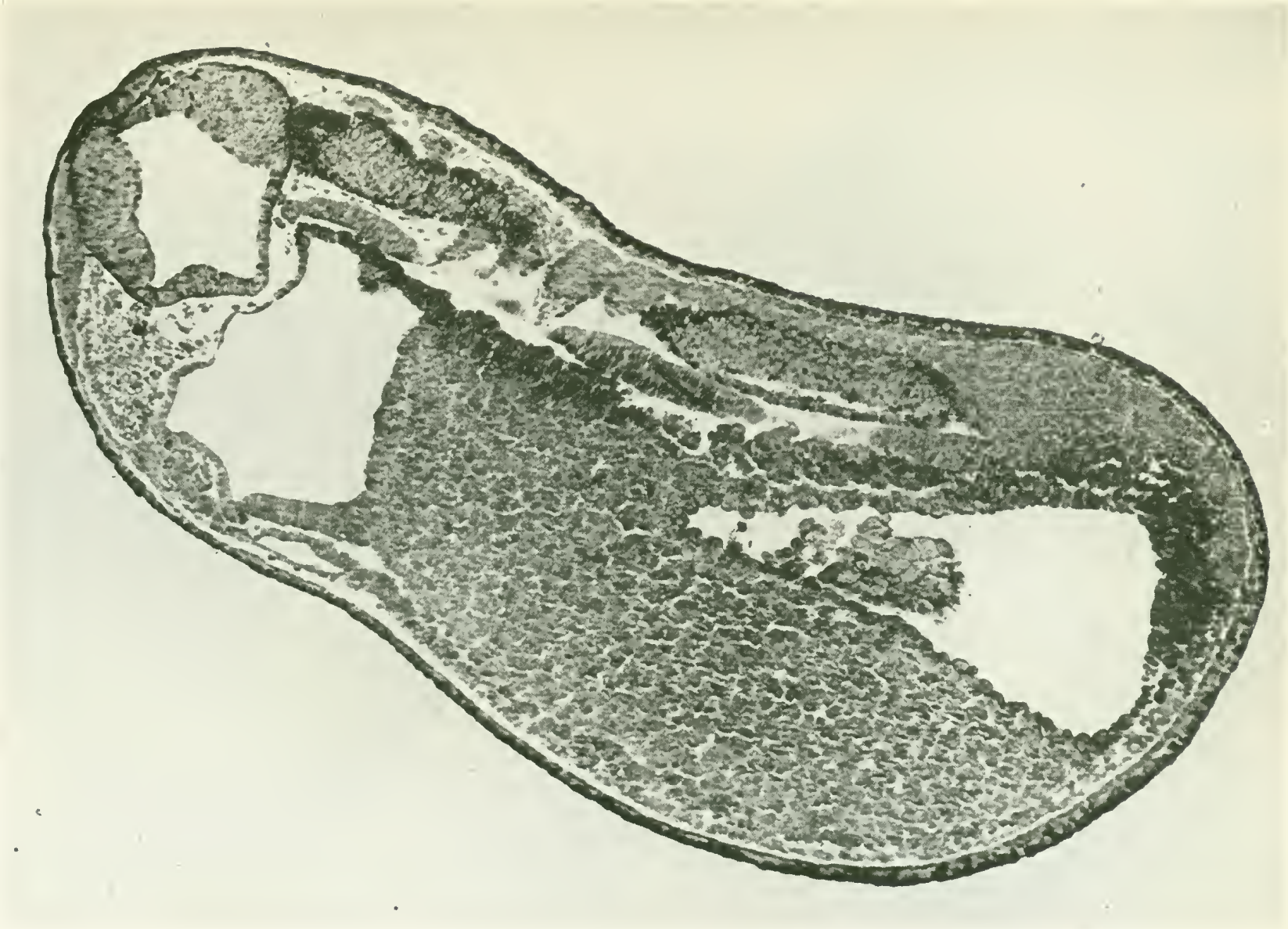
Drawing of specimen 9



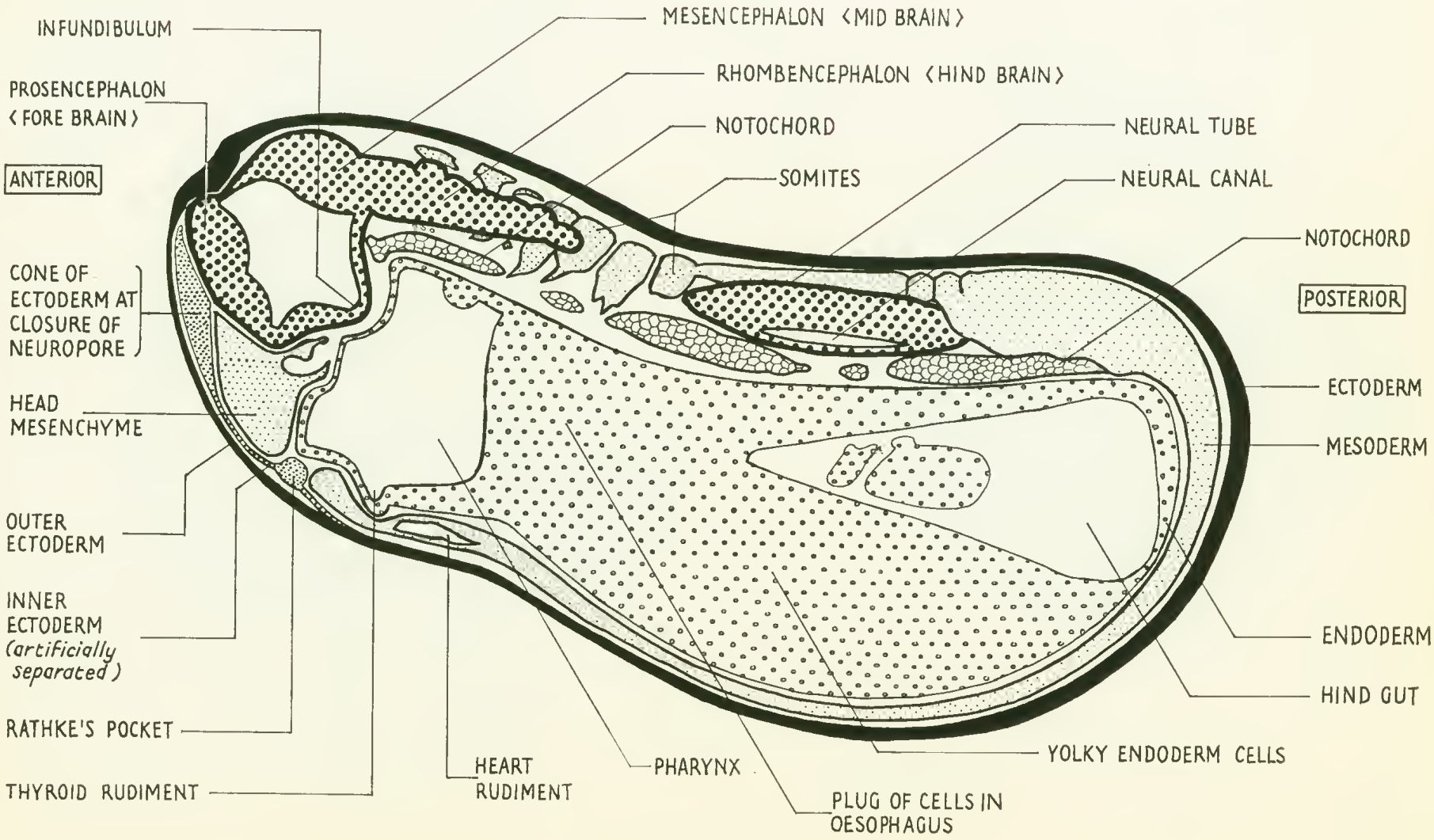
Drawing of specimen 10



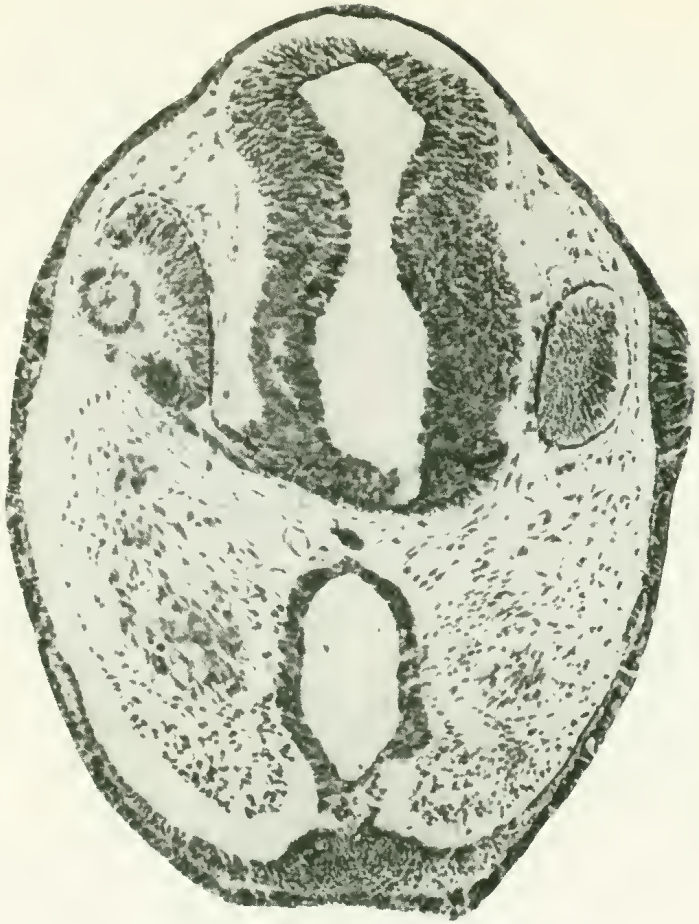
Drawing of specimen 11



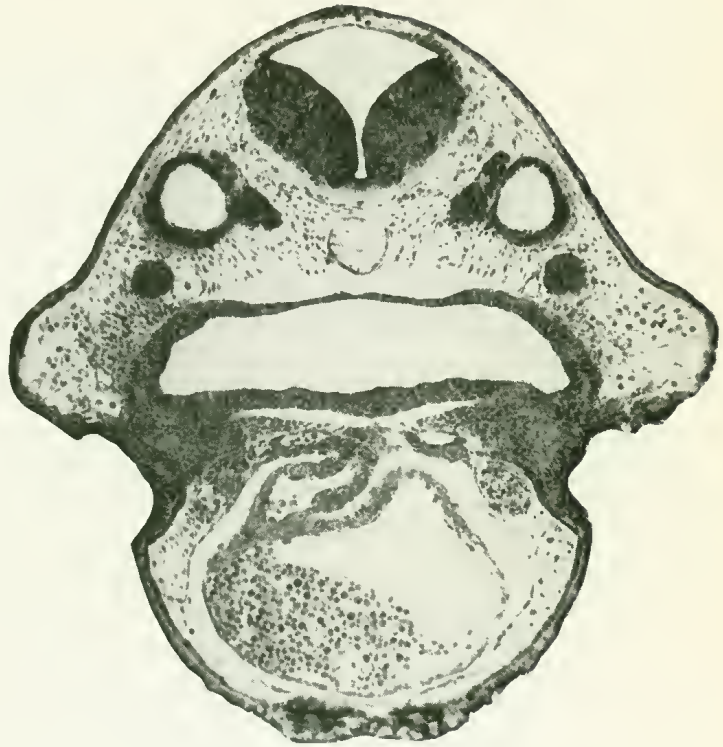
12. **Frog:** neurula, V.L.S. *mag. 60×*



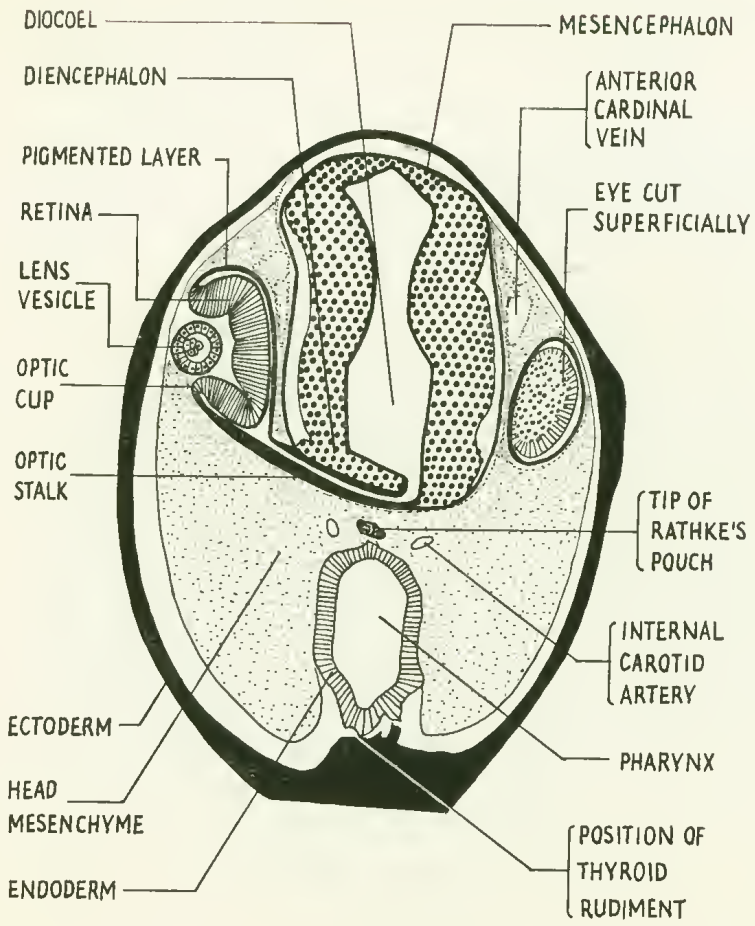
Drawing of specimen 12



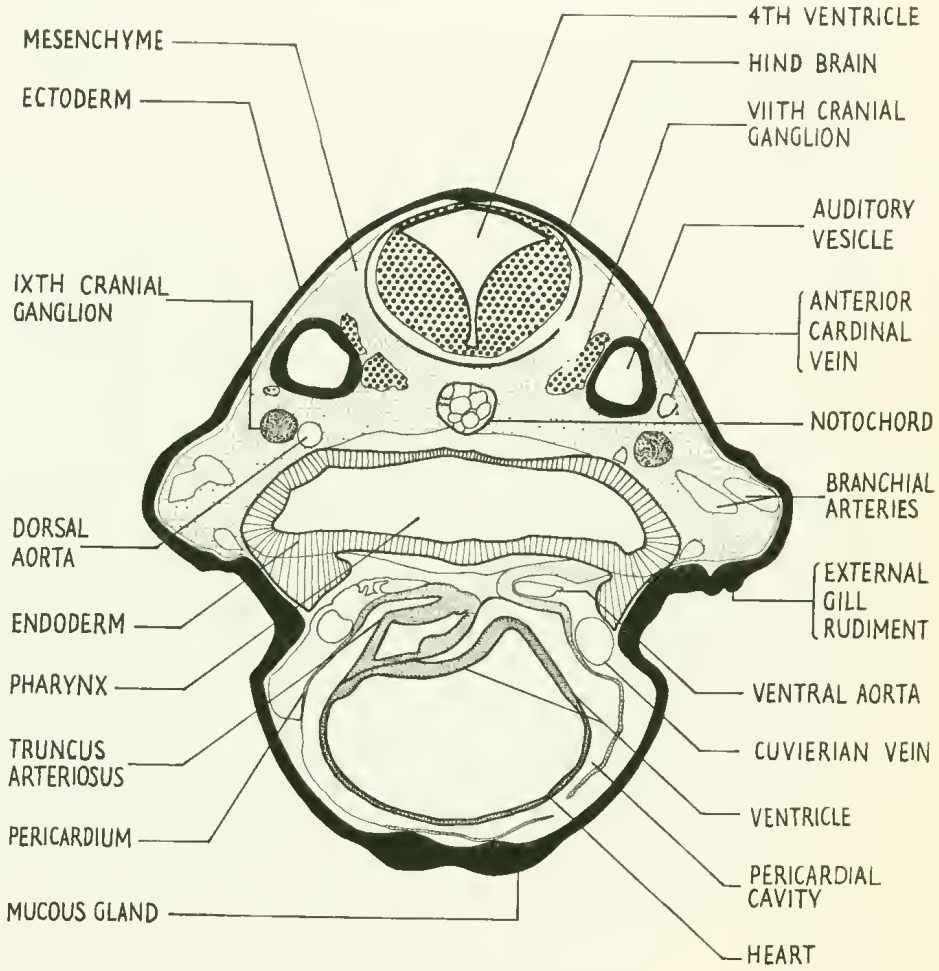
13. **Frog:** newly-hatched larva, optic region, T.S. *mag. 80*×



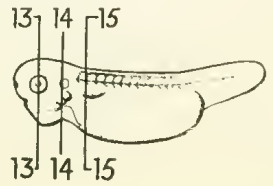
14. **Frog:** newly-hatched larva, auditory region, T.S. *mag. 55*×

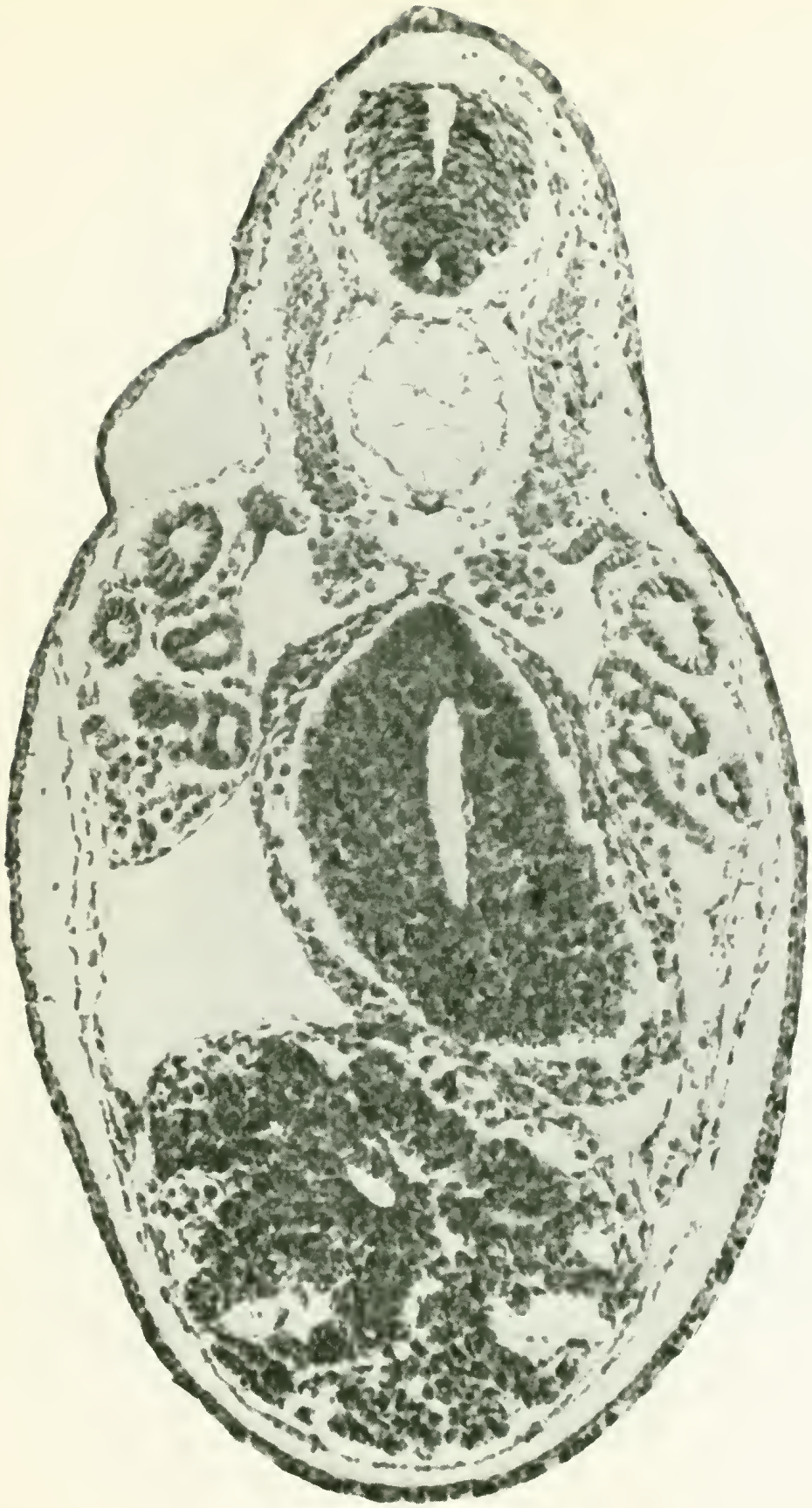


Drawing of specimen 13

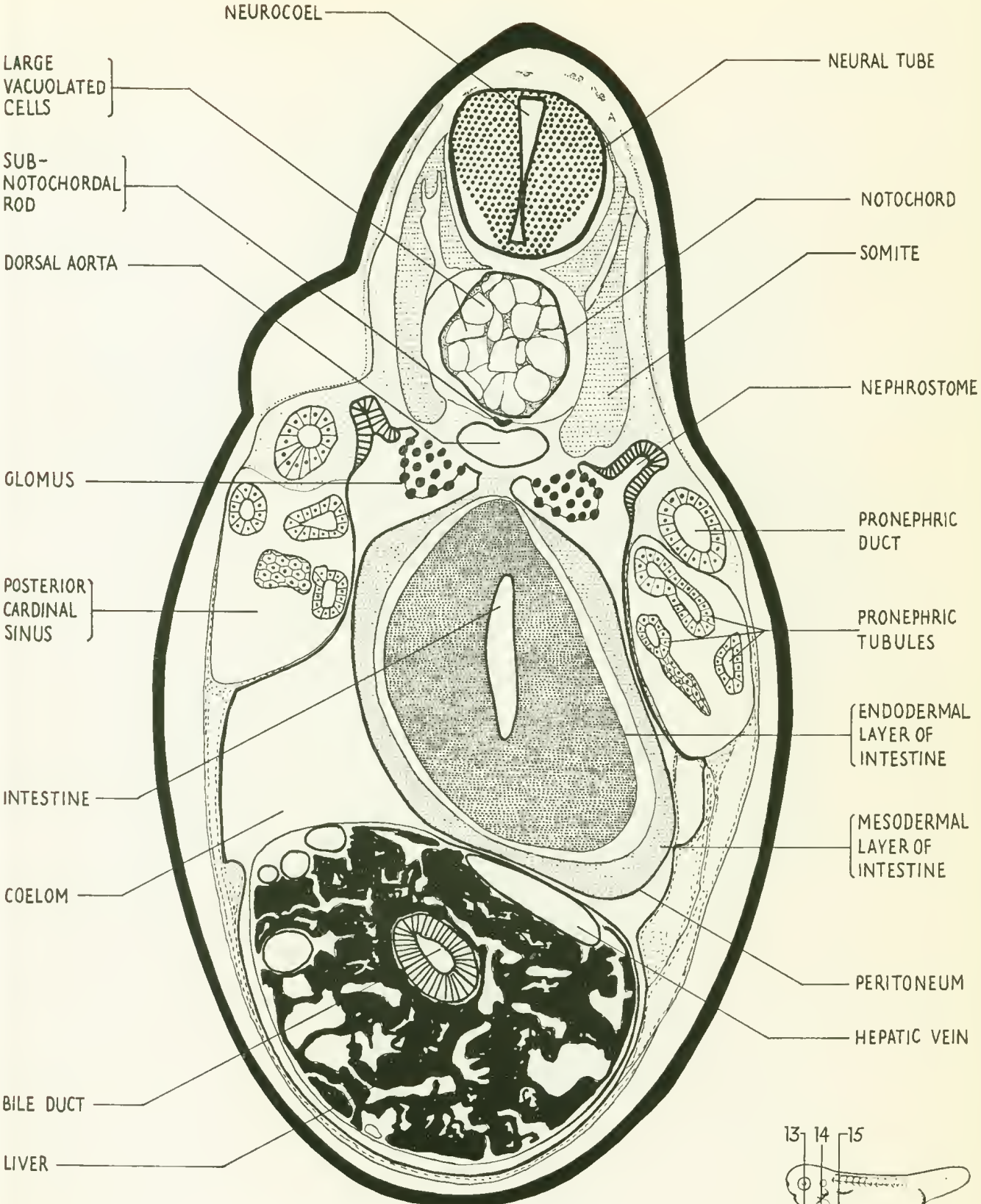


Drawing of specimen 14



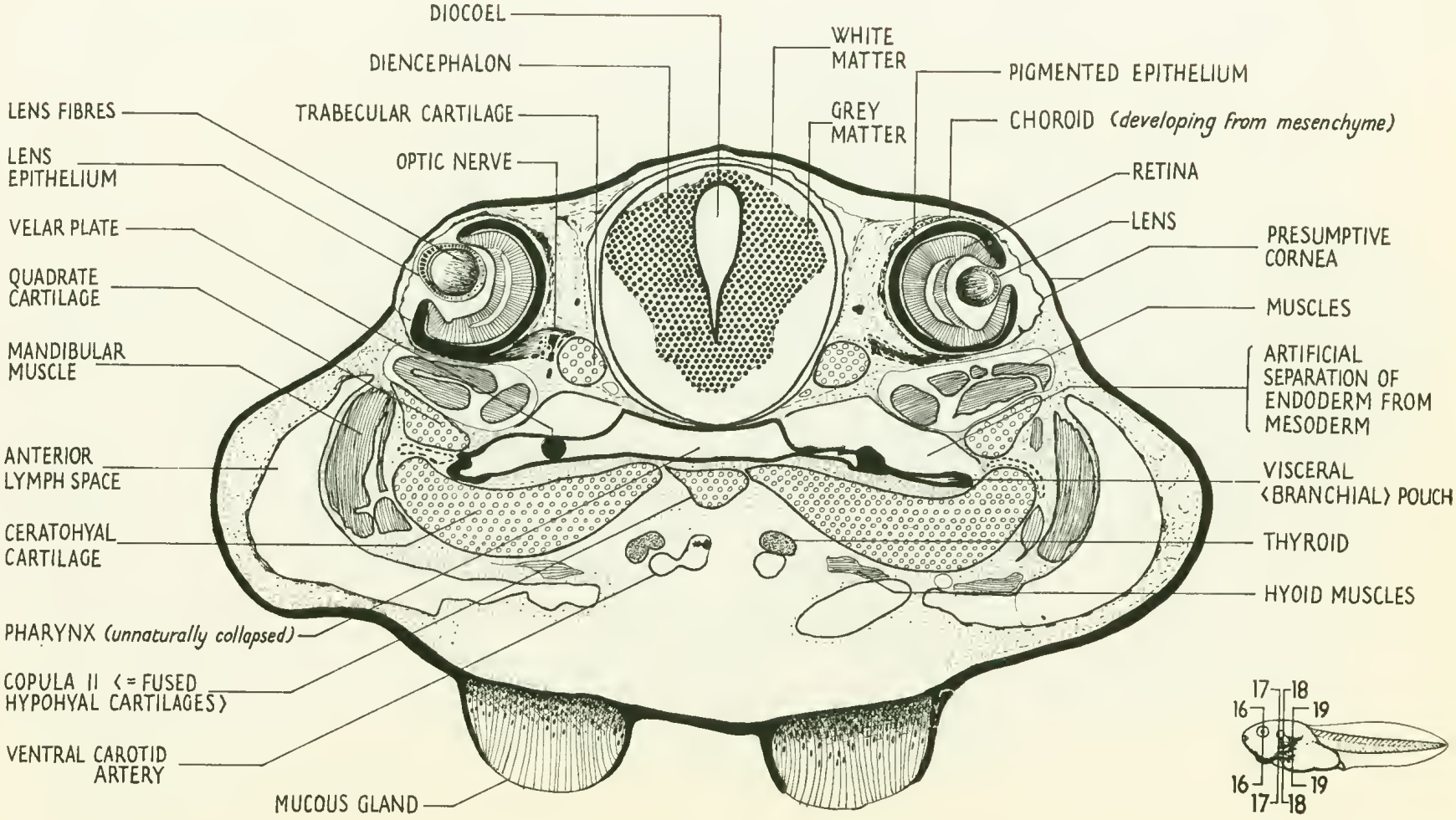


15. **Frog:** newly-hatched larva, trunk region, T.S. *mag. 130*×

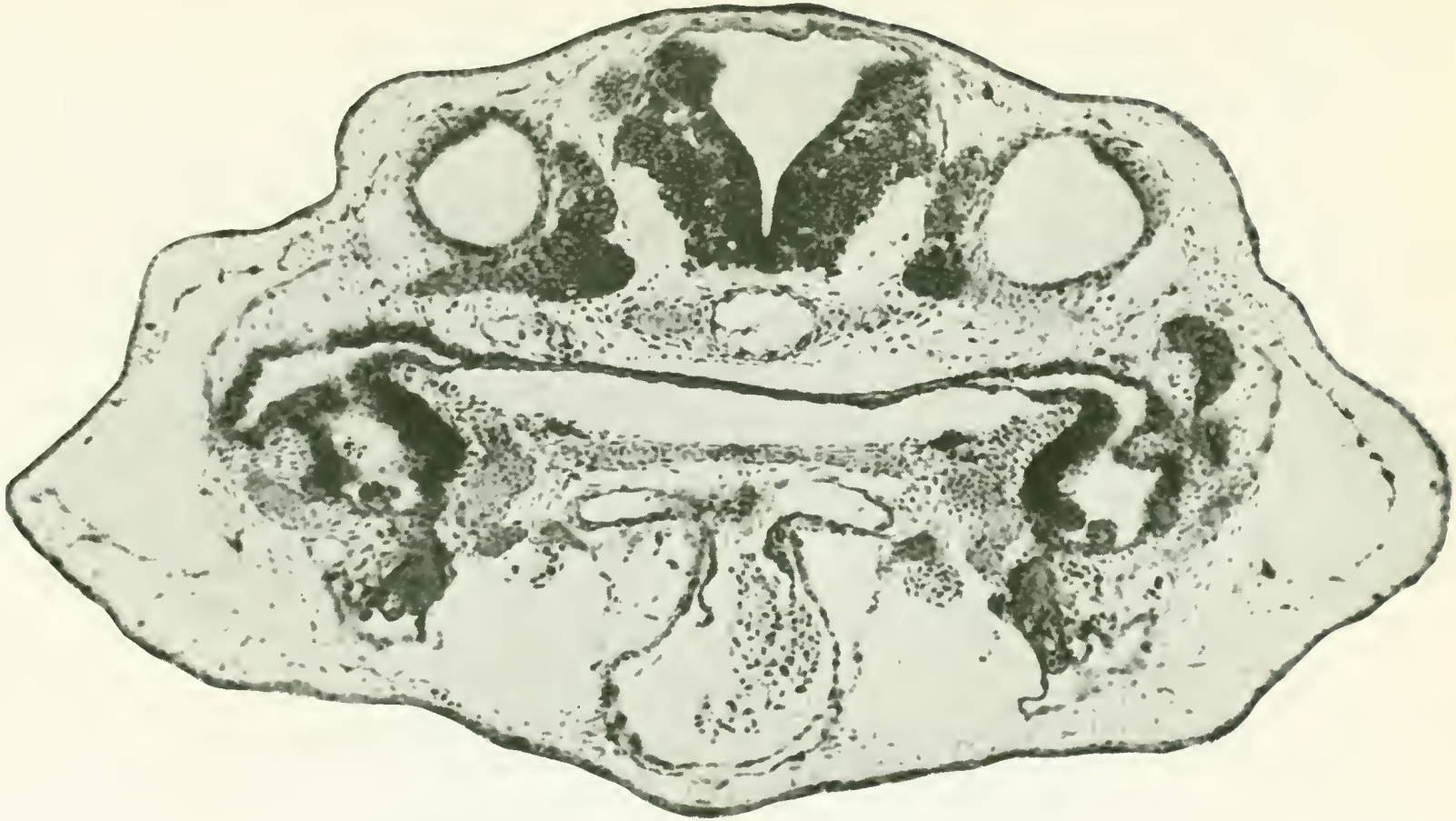


Drawing of specimen 15

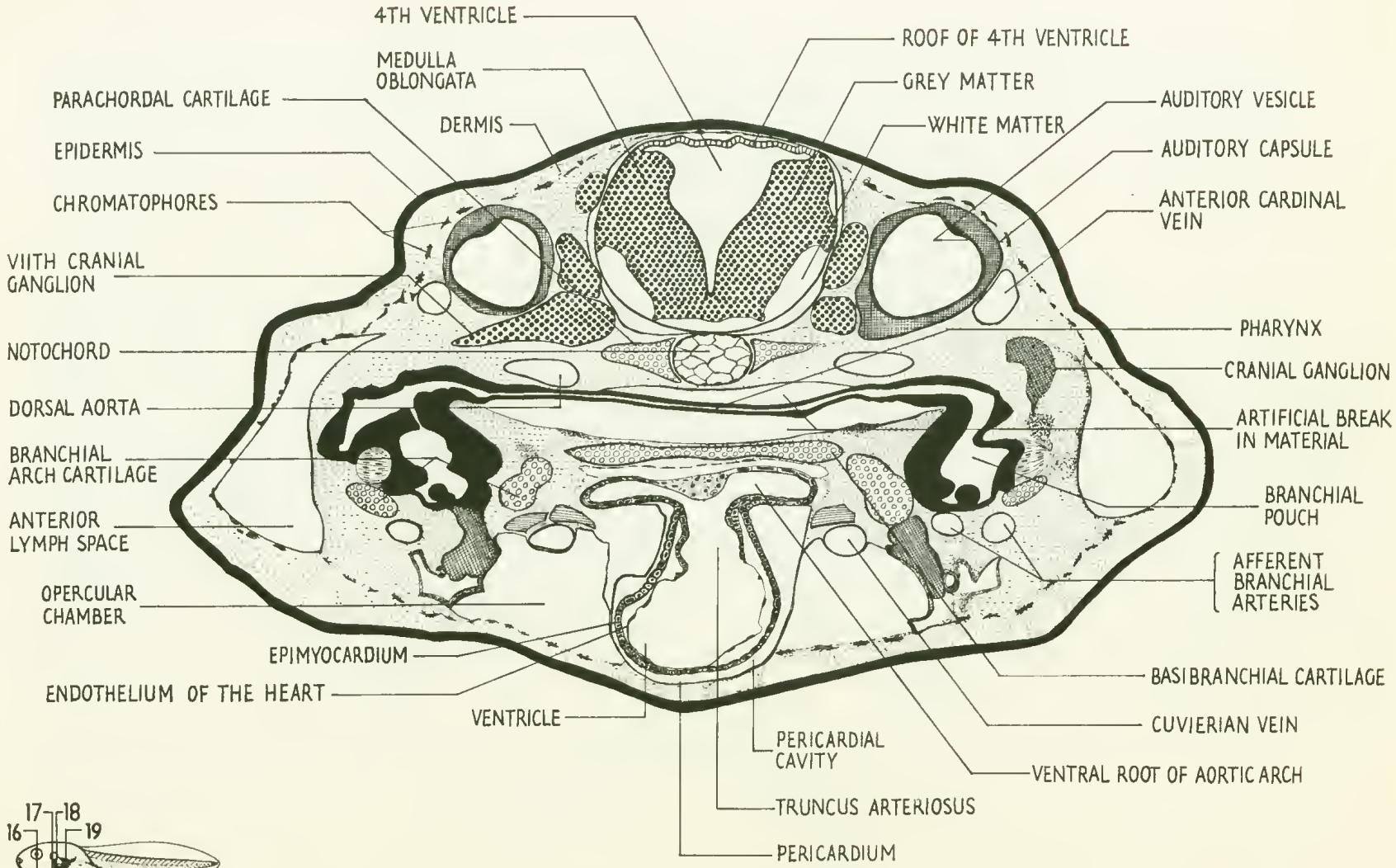
16. **Frog:** external gill larva, optic region, T.S. *mag. 100*×



Drawing of specimen 16

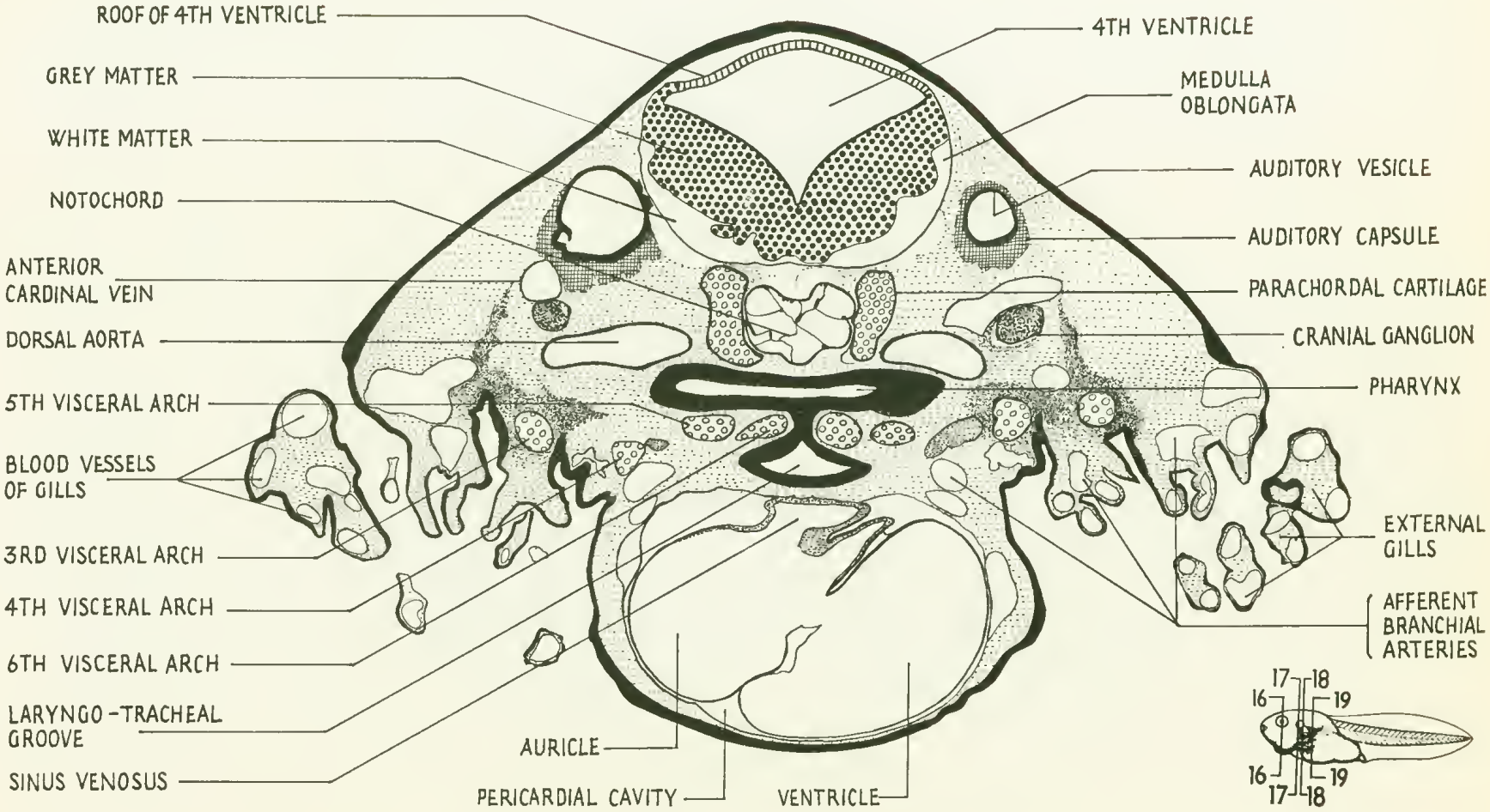


17. **Frog:** external gill larva, auditory region, T.S. *mag. 100*×

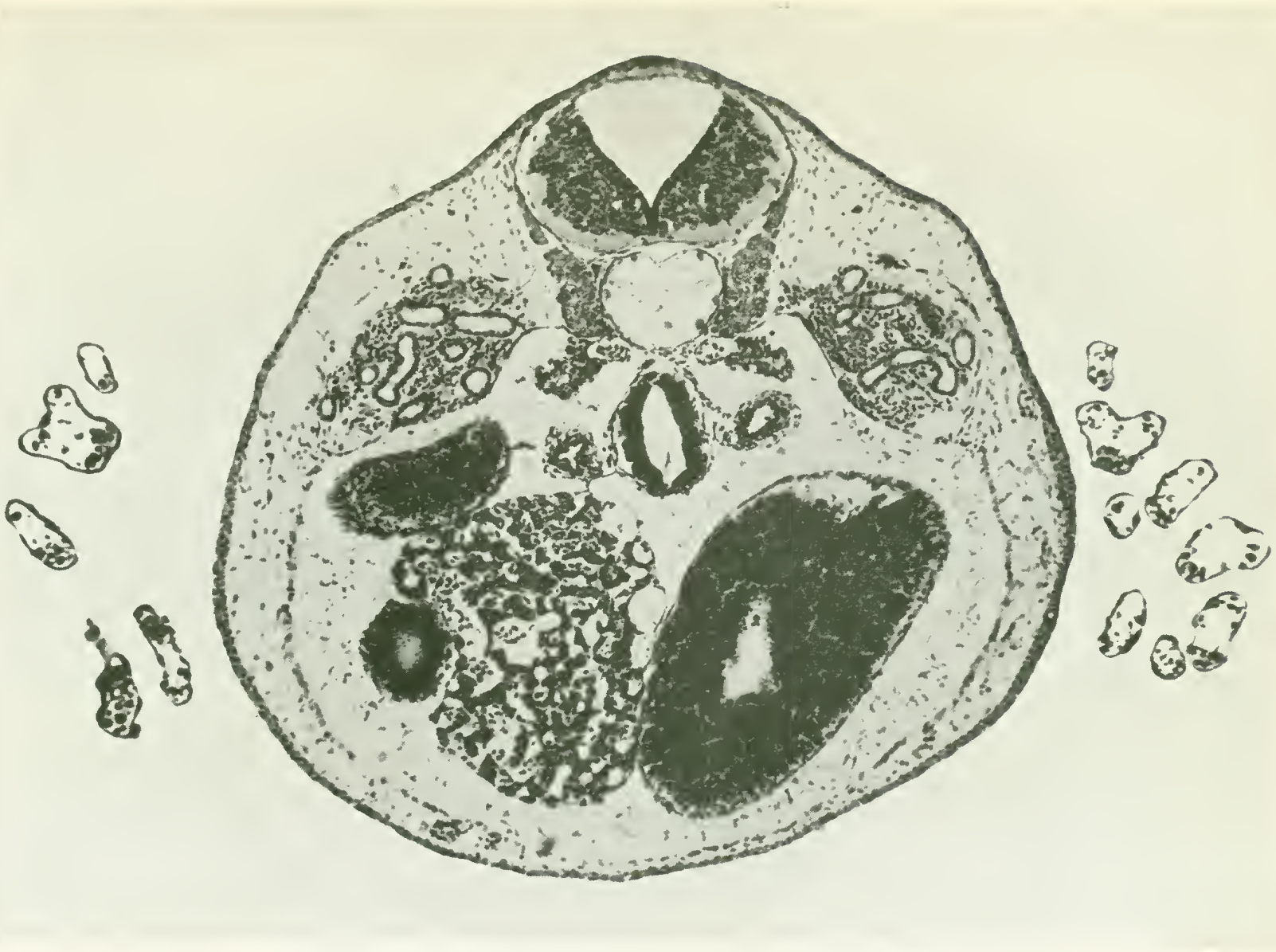


Drawing of specimen 17

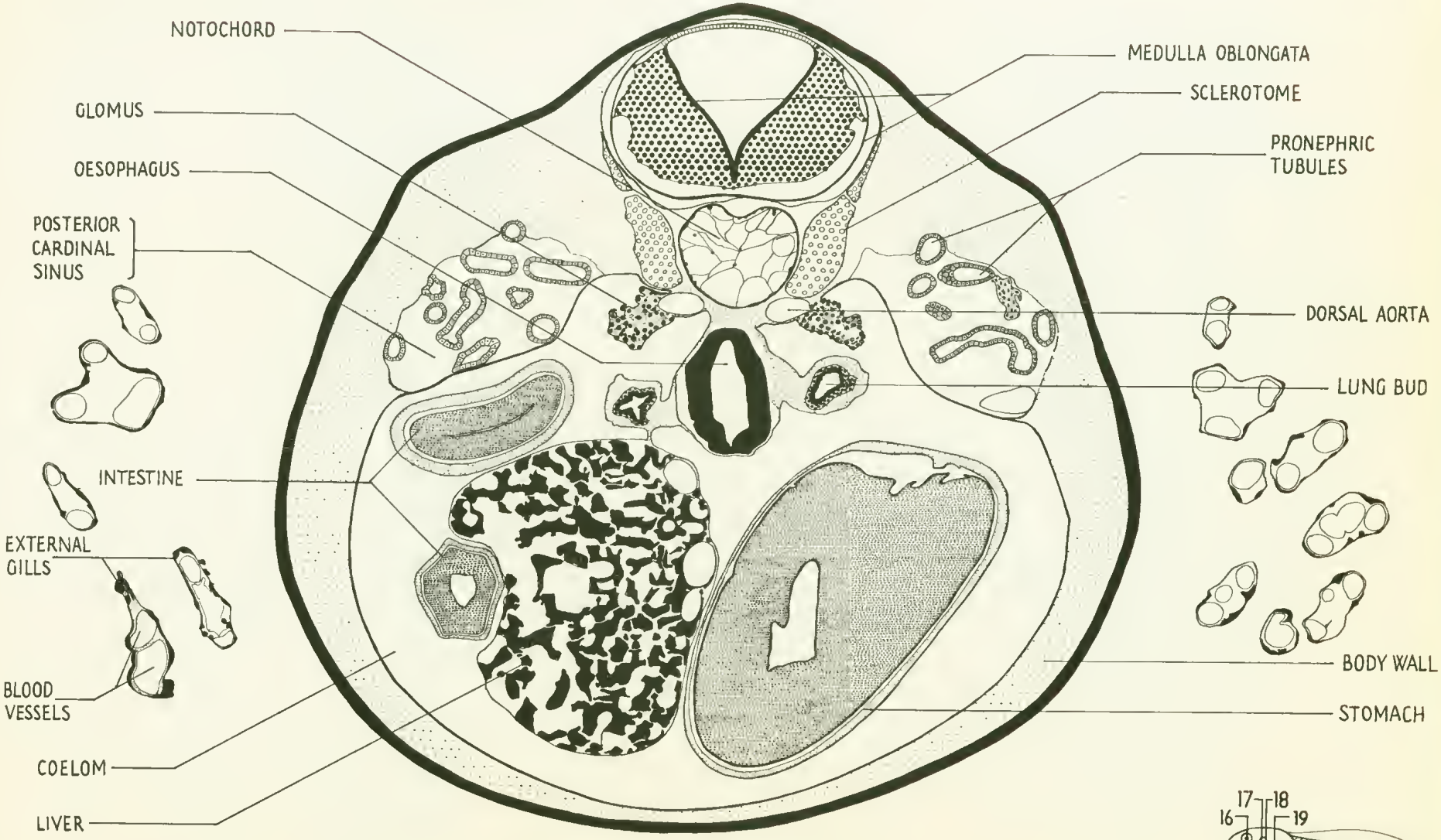
18. **Frog:** external gill larva, heart and gill region, T.S. *mag. 120*×



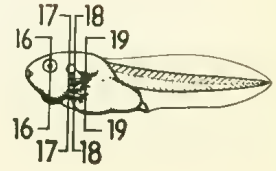
Drawing of specimen 18

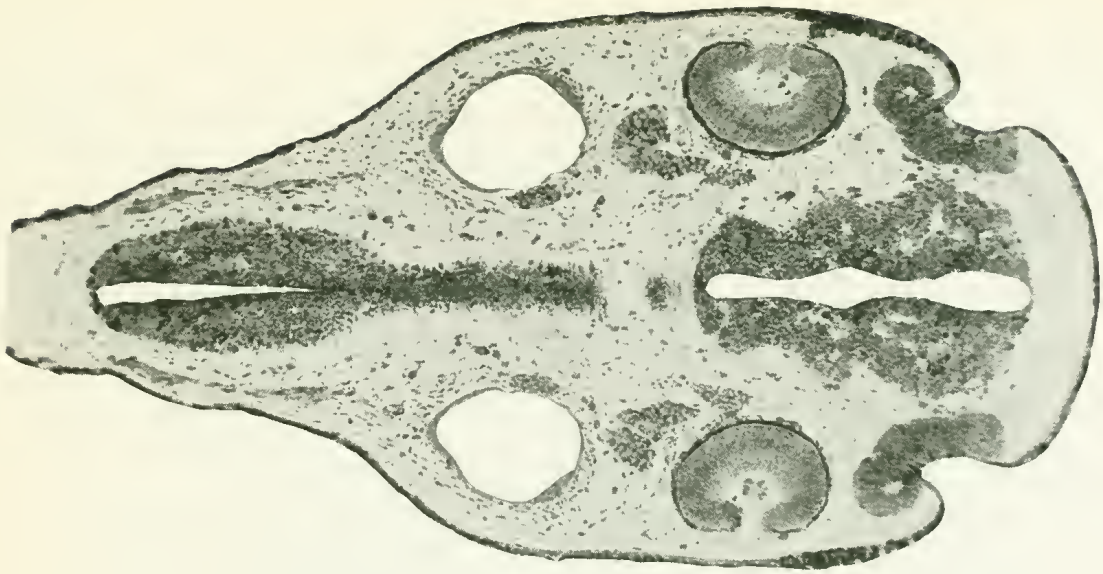


19. **Frog:** external gill larva, trunk region, T.S. *mag. 80*×

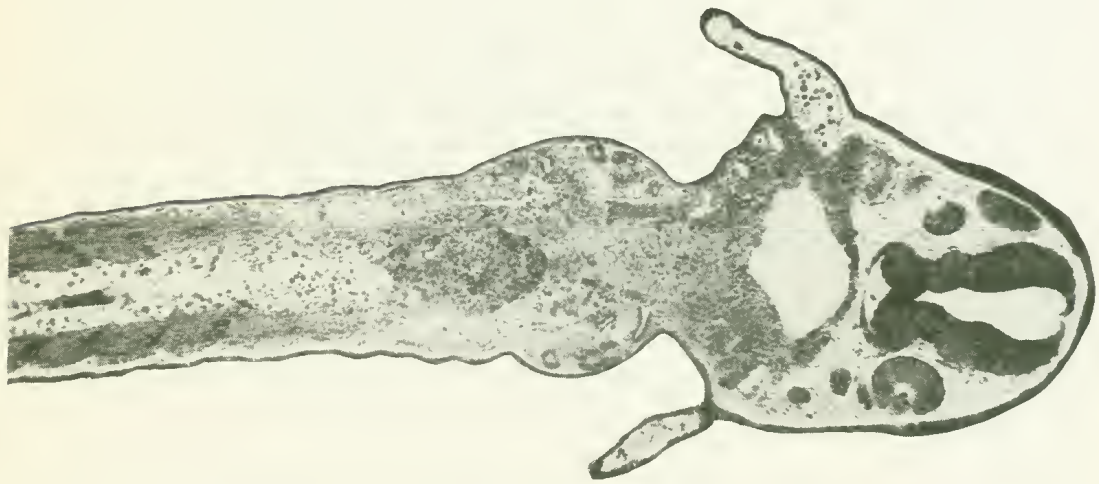


Drawing of specimen 19

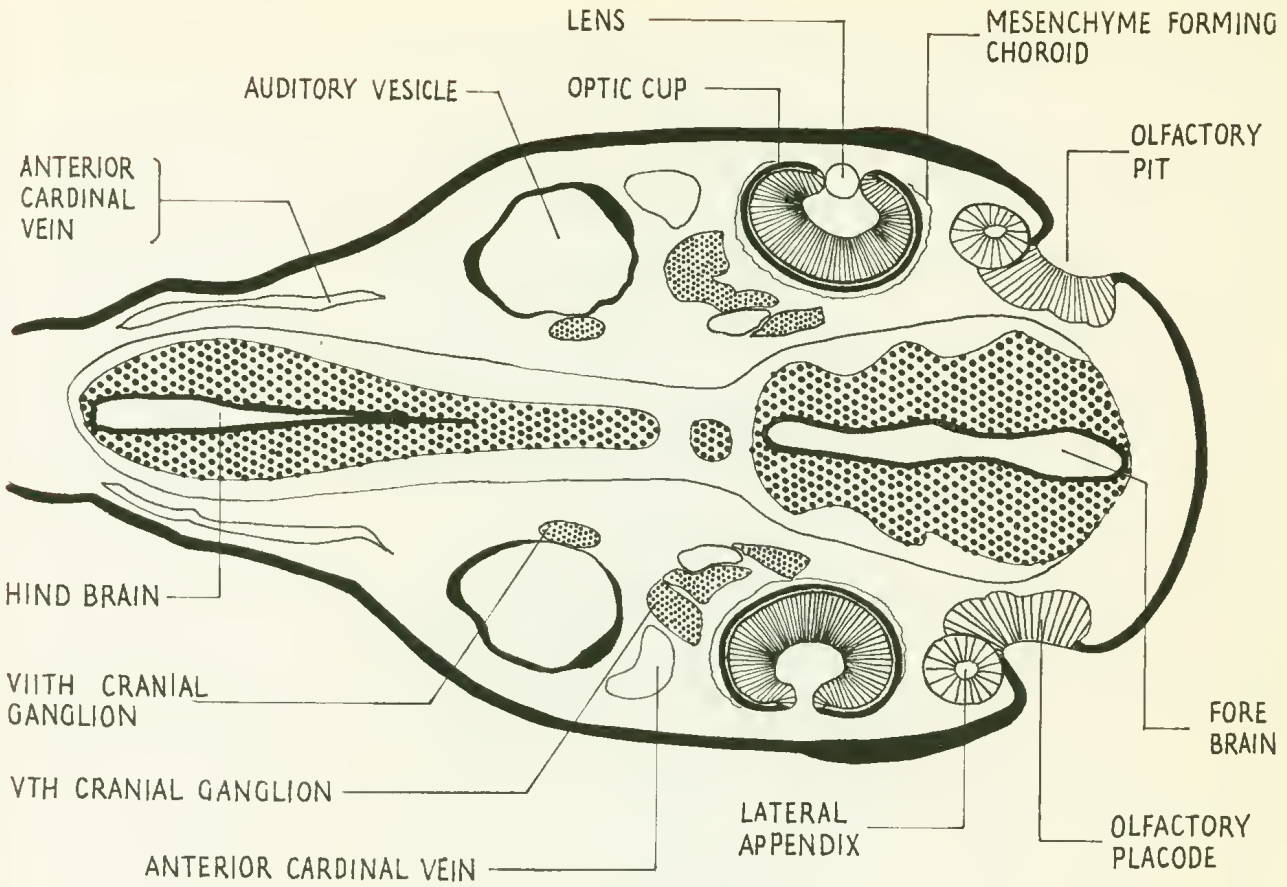




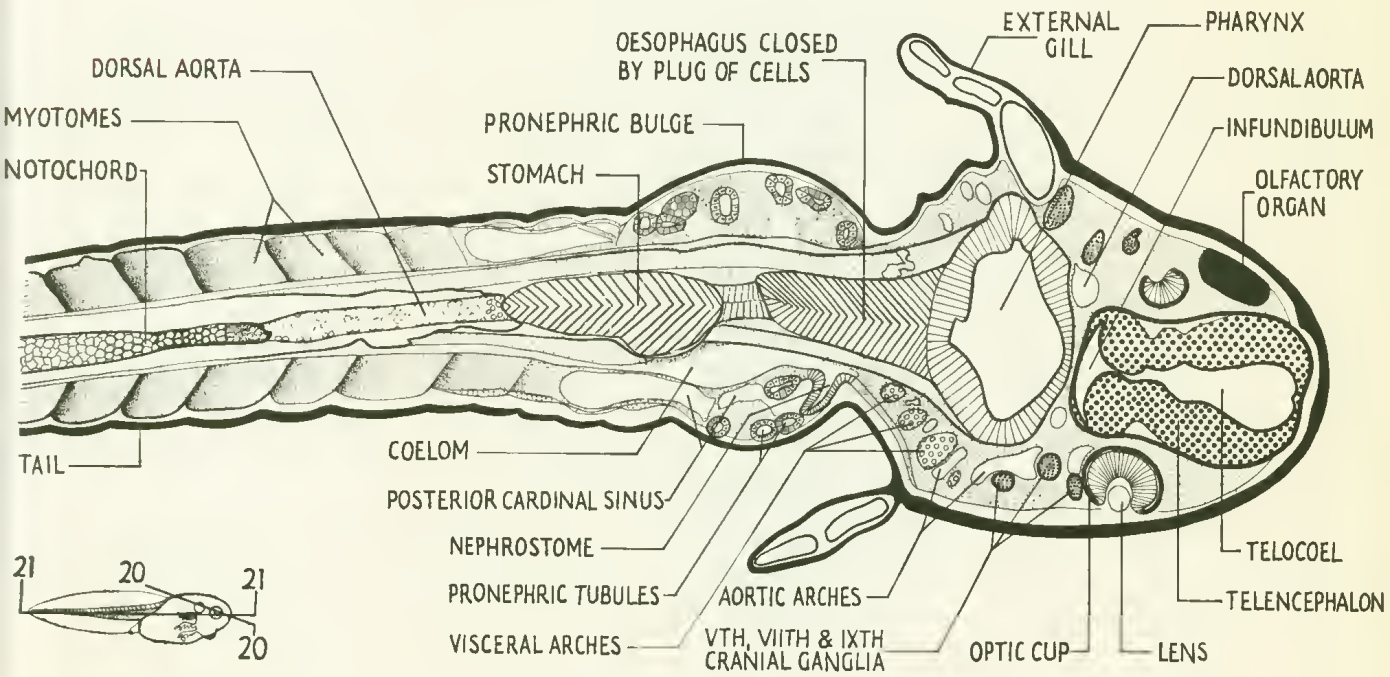
20. **Frog:** external gill larva, head region, H.L.S. *mag. 85*×



21. **Frog:** external gill larva, trunk region, H.L.S. *mag. 50*×

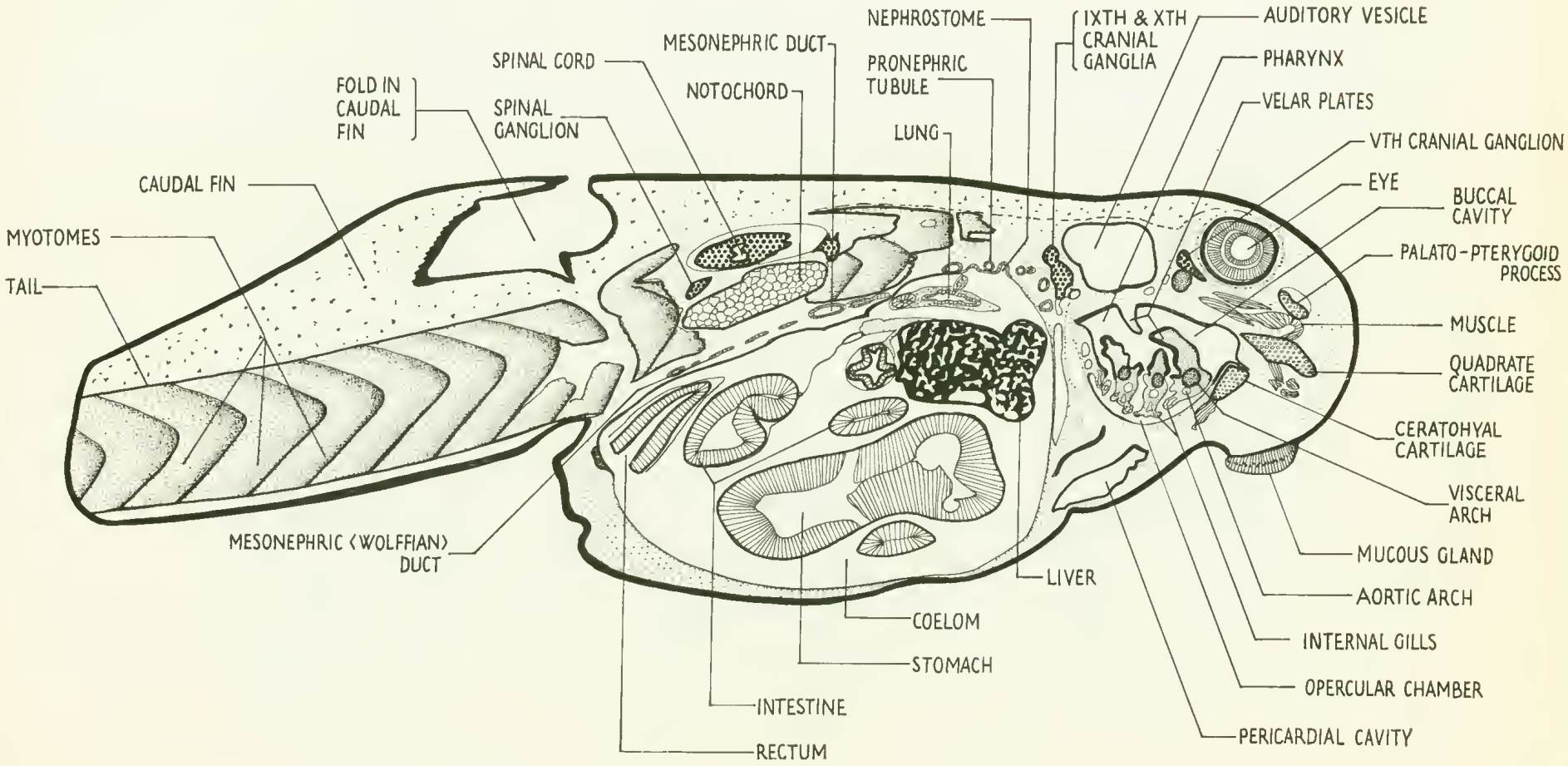


Drawing of specimen 20



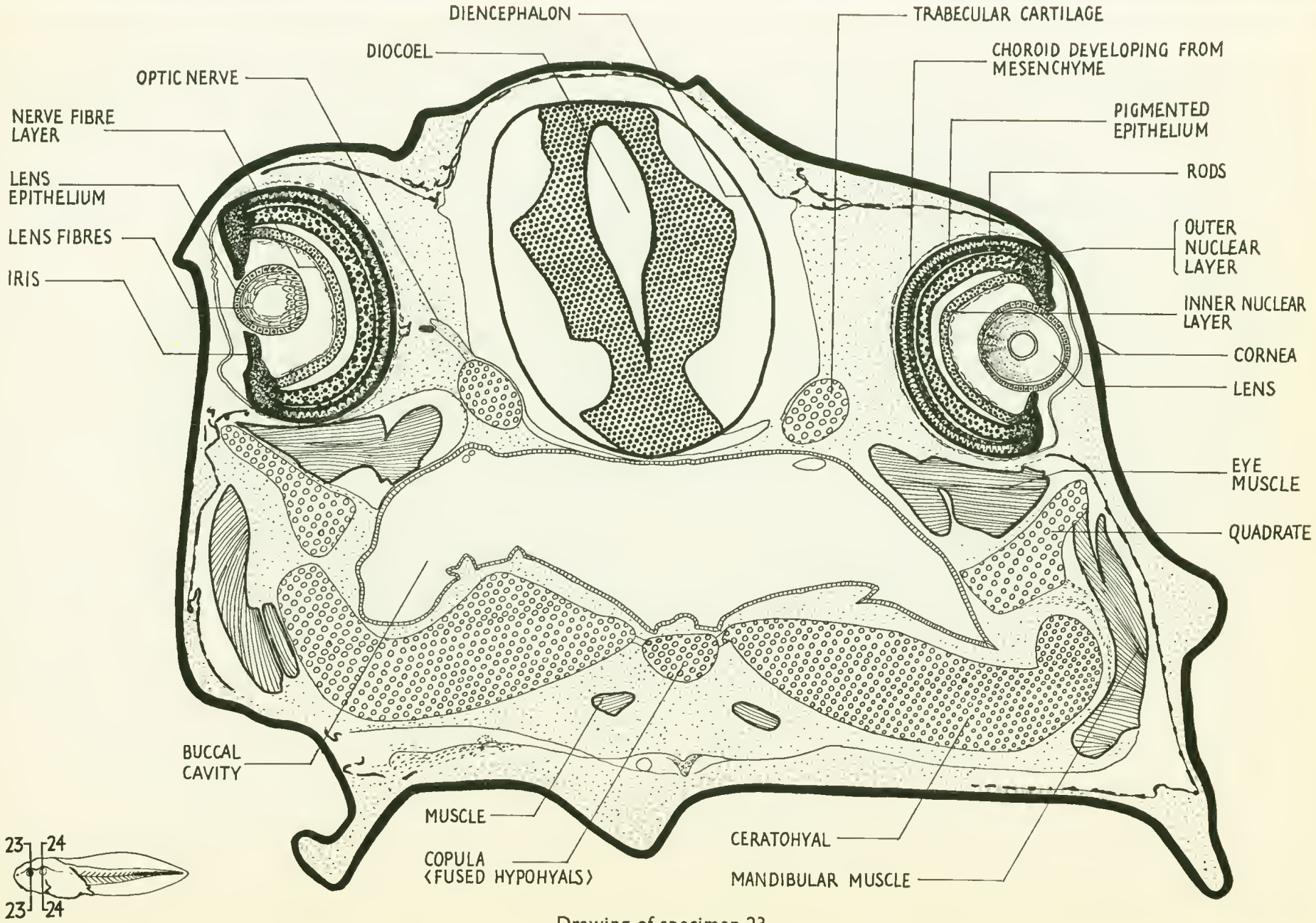
Drawing of specimen 21

22. **Frog:** internal gill larva, trunk region, V.L.S. *mag. 40×*



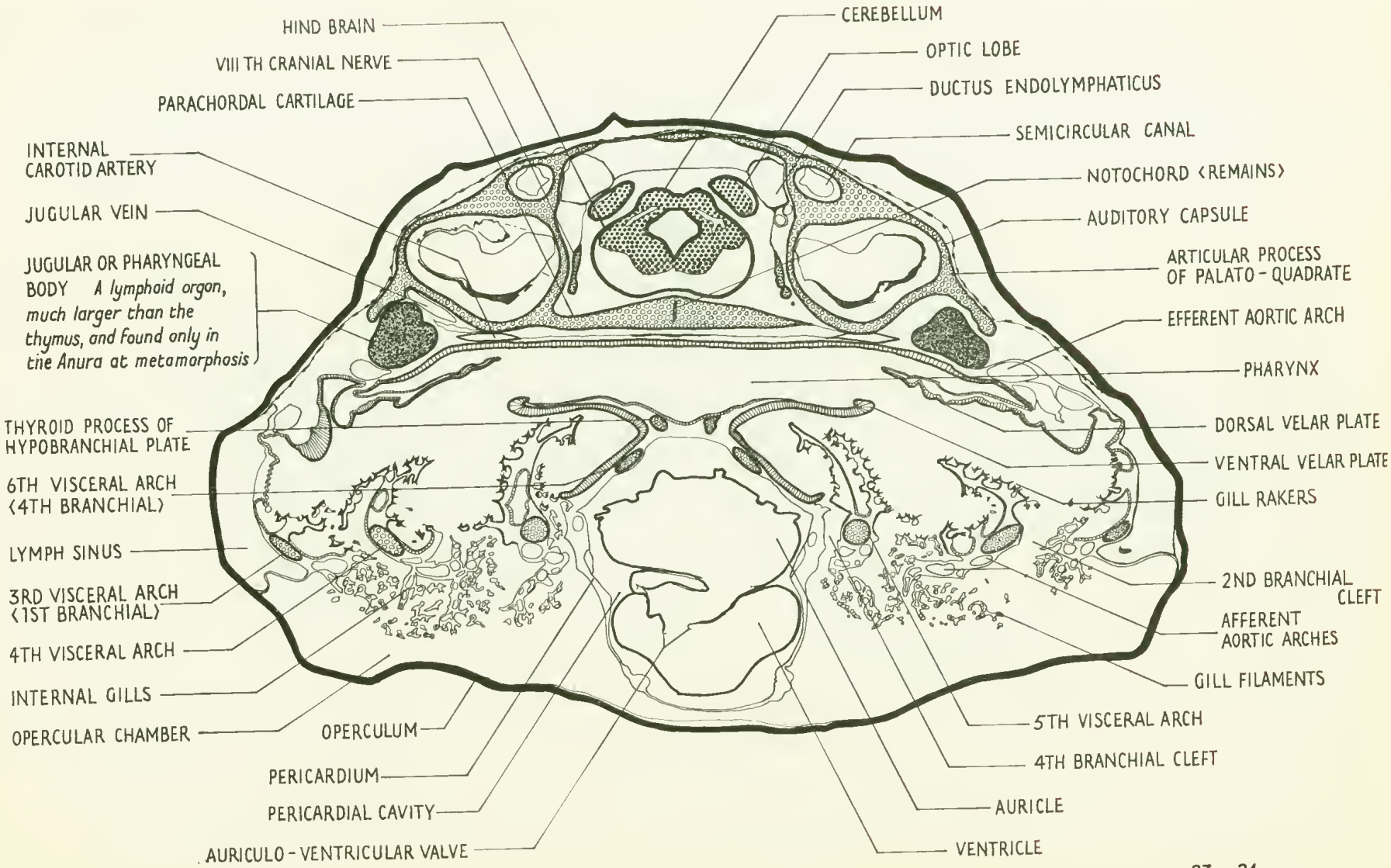
Drawing of specimen 22

23. **Frog:** internal gill larva, optic region, T.S. *mag. 80*×

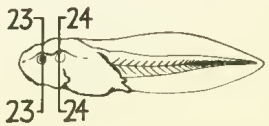


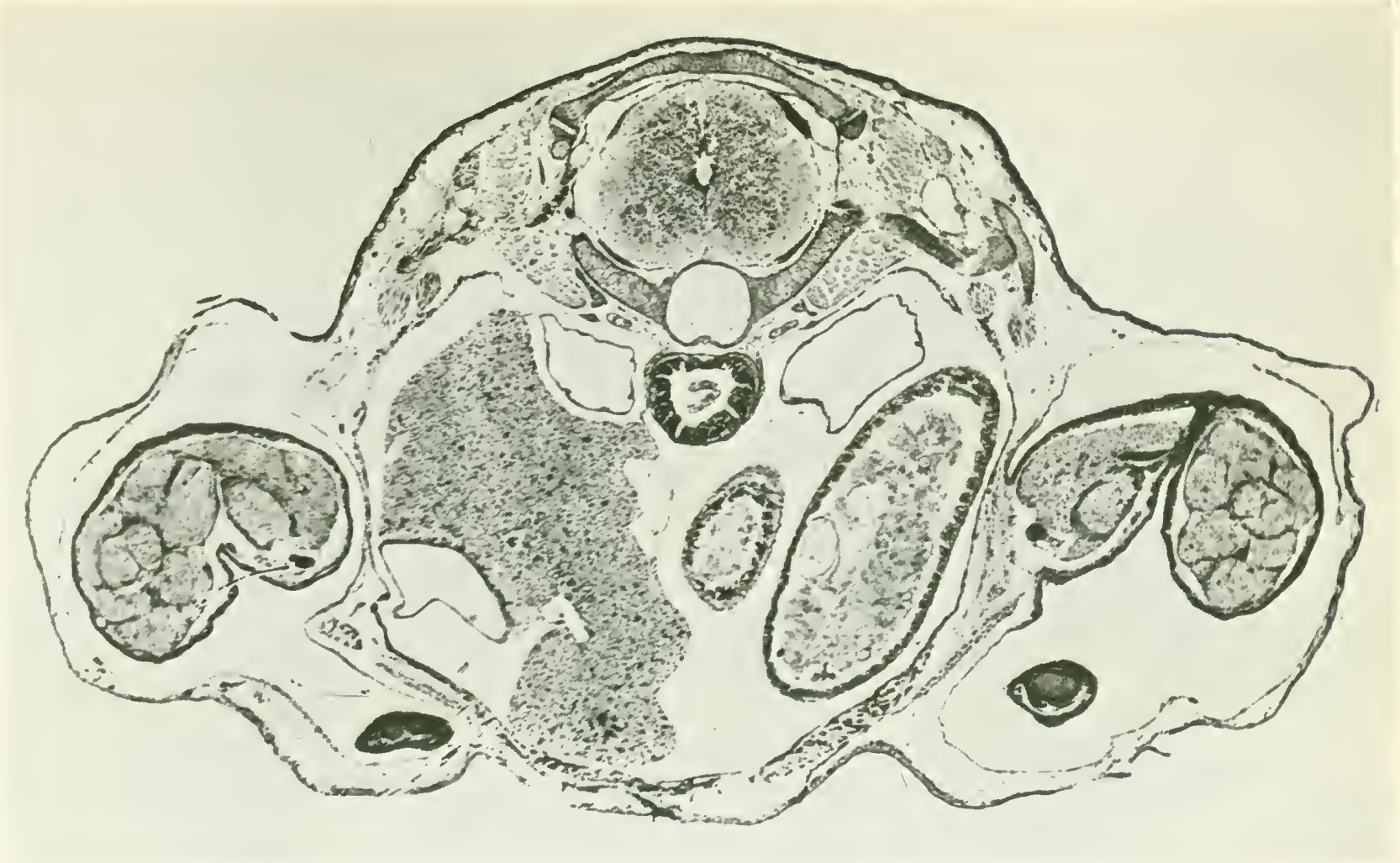
Drawing of specimen 23

24. **Frog:** internal gill larva, Gill region, T.S. *mag. 45*

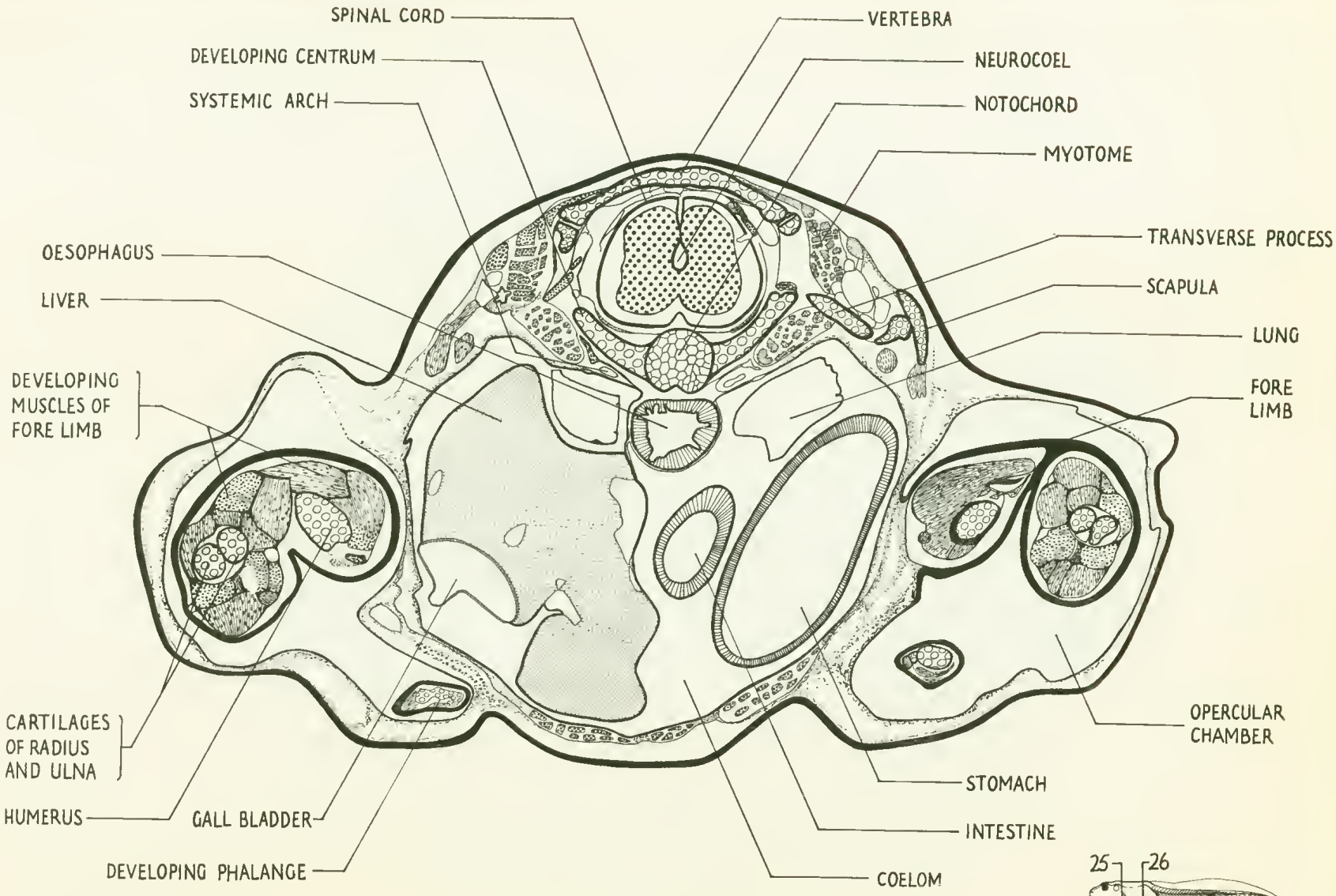


Drawing of specimen 24

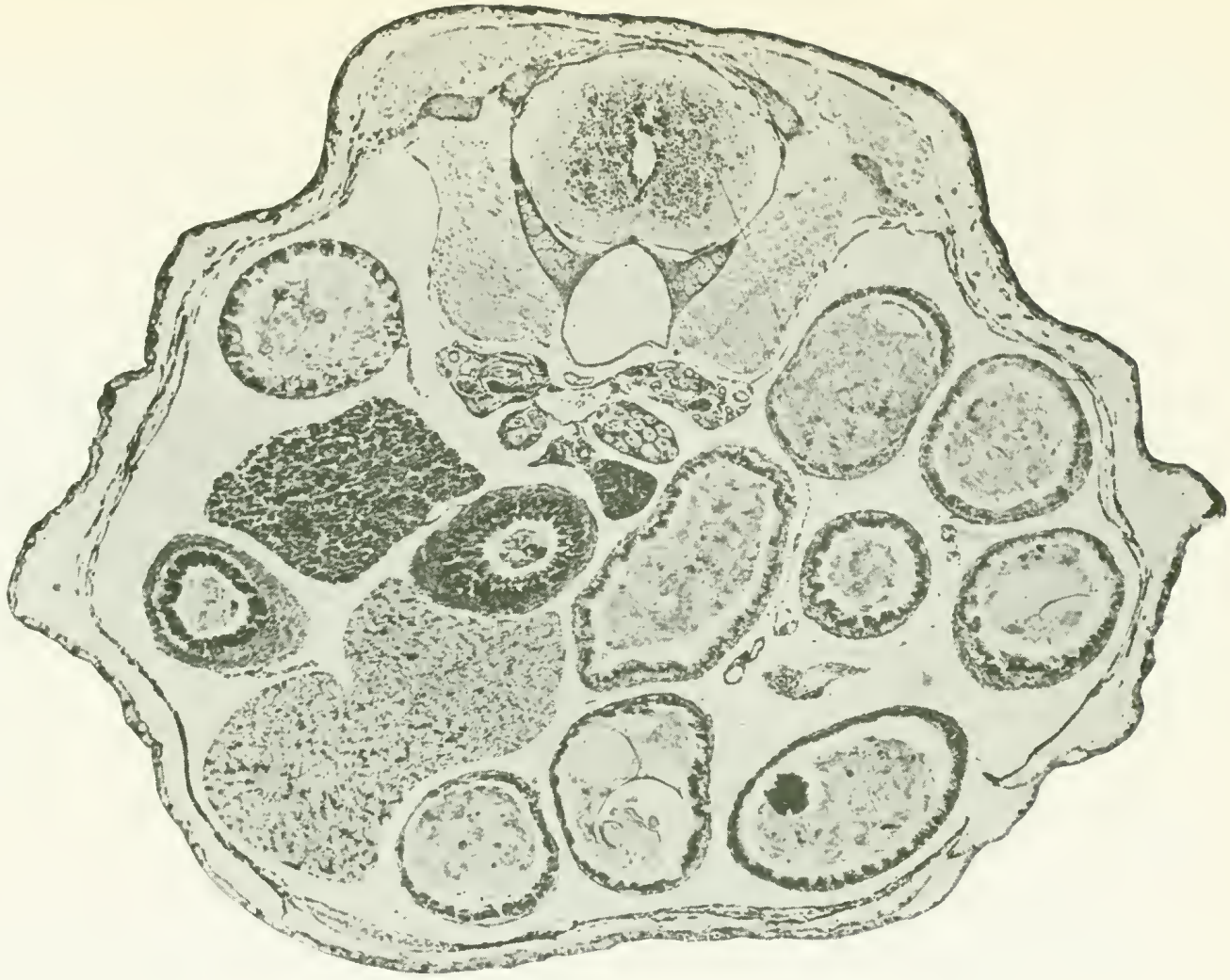




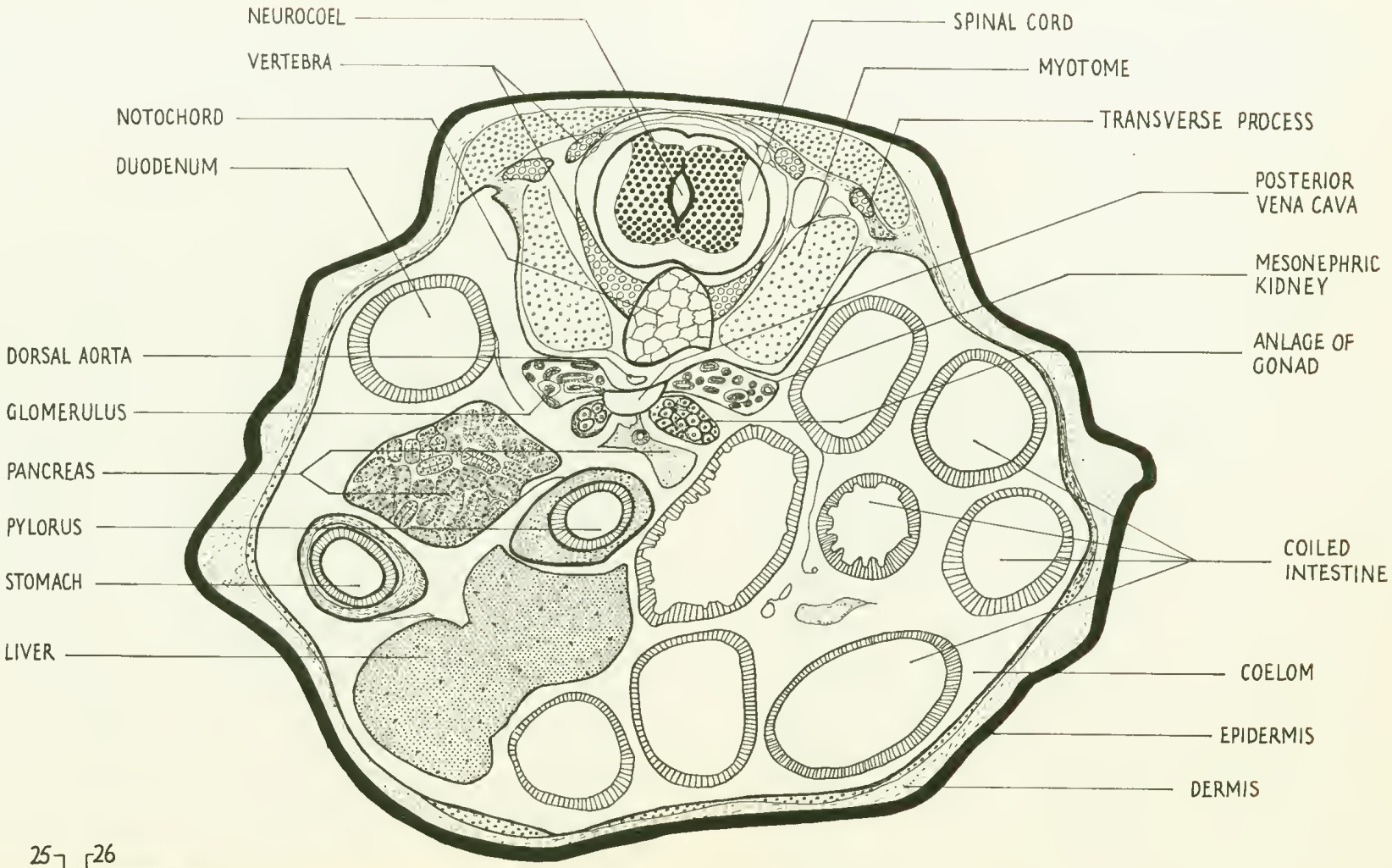
25. **Frog:** 19-mm. tadpole, forelimb region, T.S. *mag.* 35×

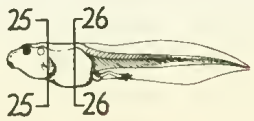


Drawing of specimen 25



26. **Frog:** 19-mm. tadpole, trunk region, T.S. *mag. 40×*

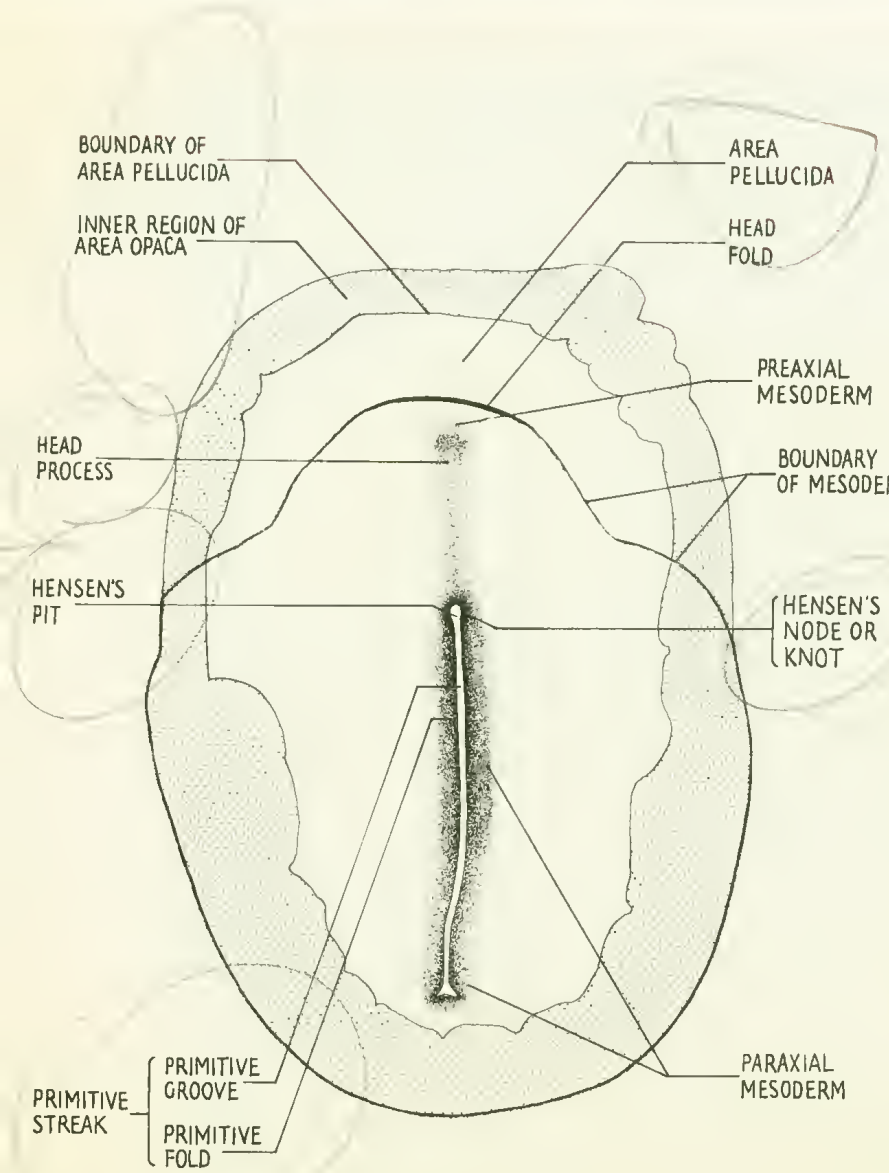




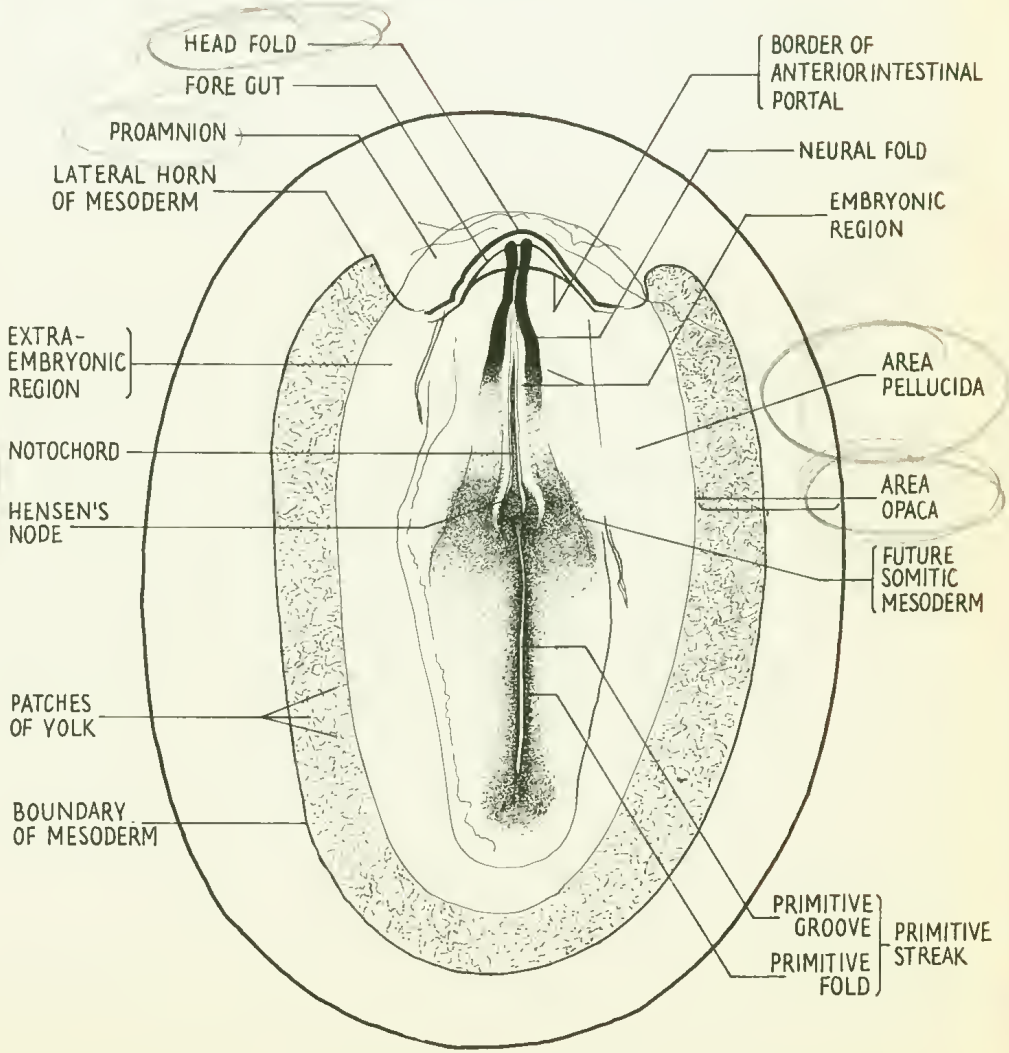
Drawing of specimen 26

27. **Chick:** blastoderm, head-process stage, E. *mag.* 25×

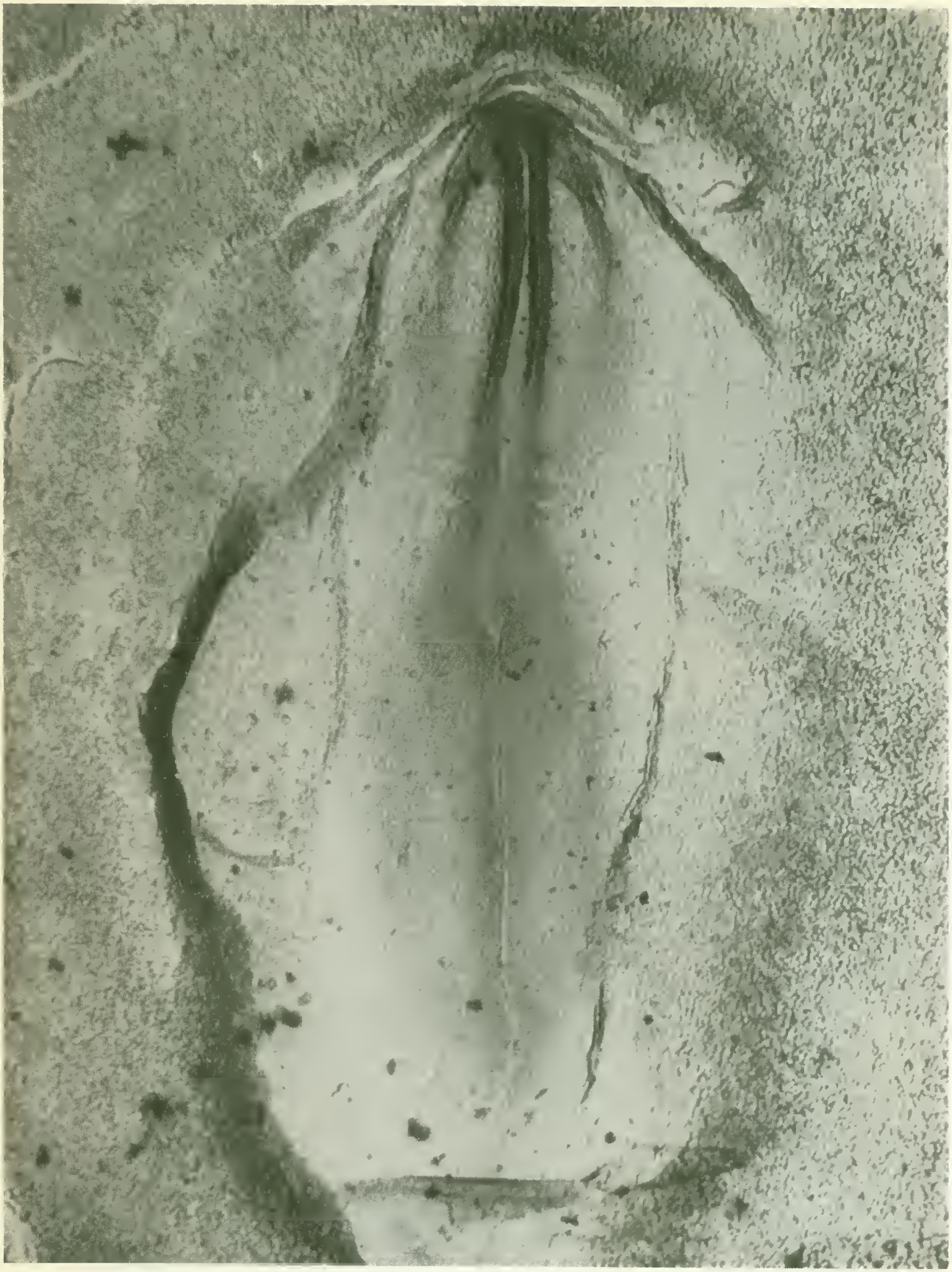
28. **Chick:** blastoderm, head-fold stage, E. *mag.* 25×



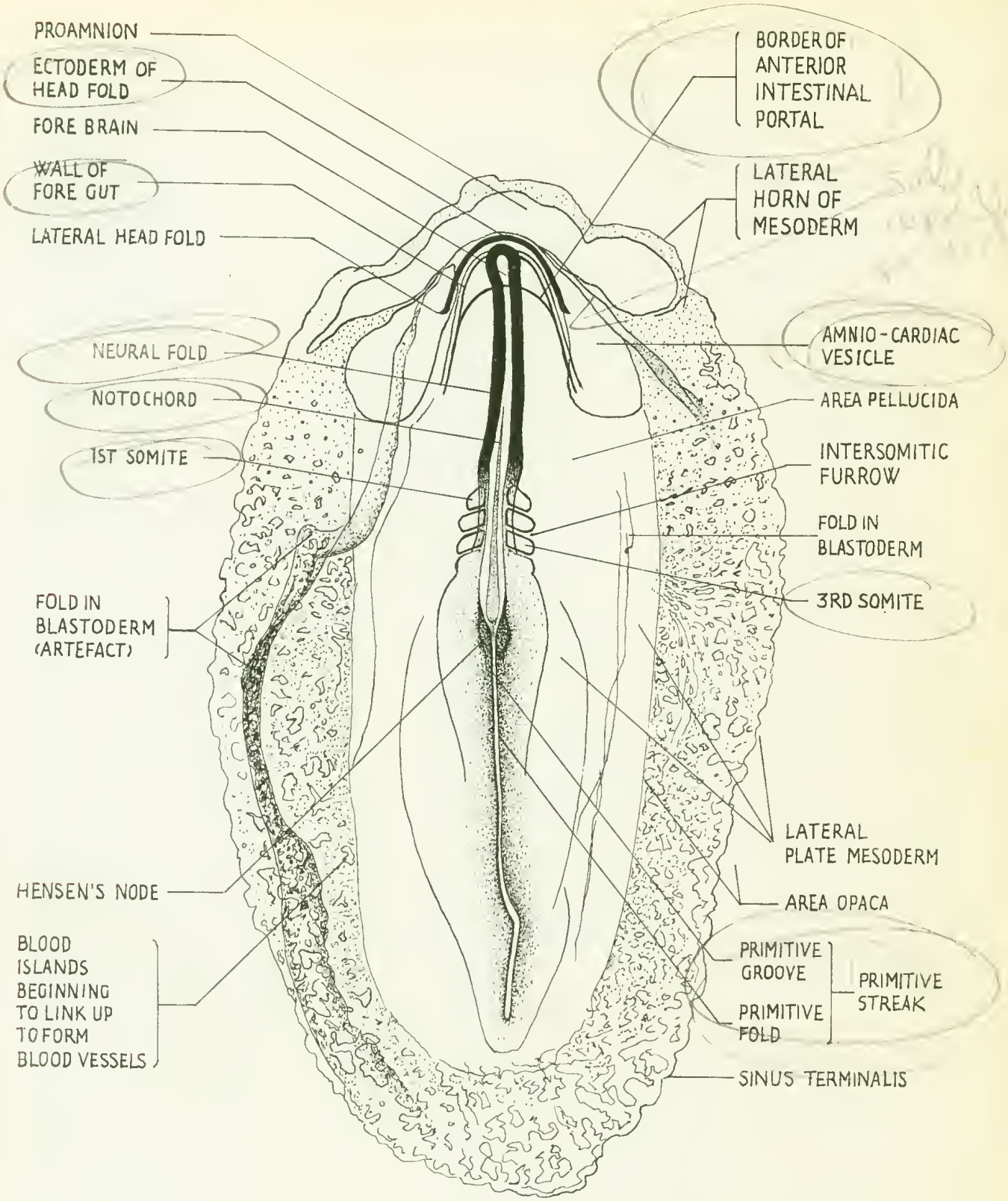
Drawing of specimen 27



Drawing of specimen 28

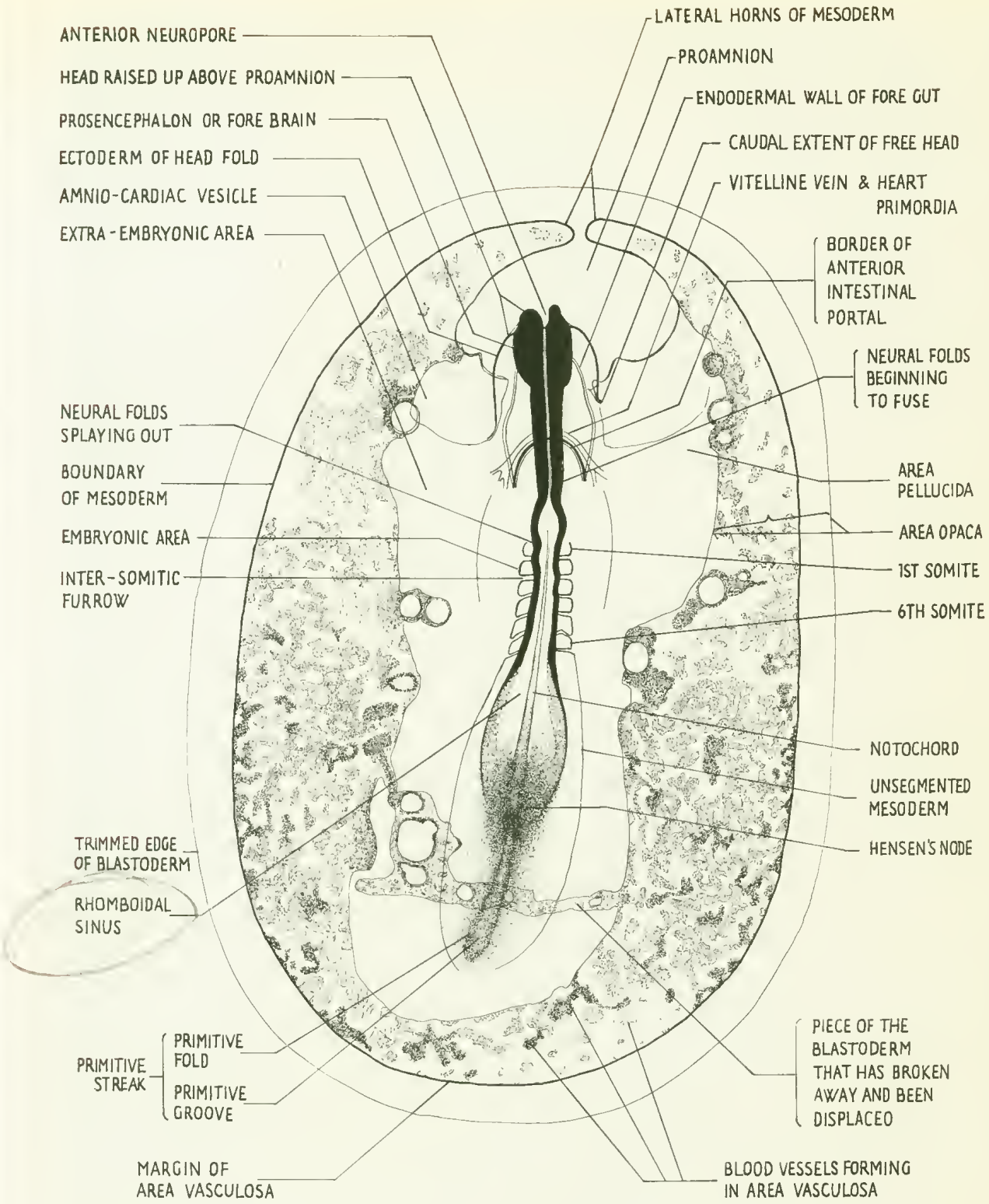


29. **Chick:** blastoderm, 3-somite, E. *mag. 40*×

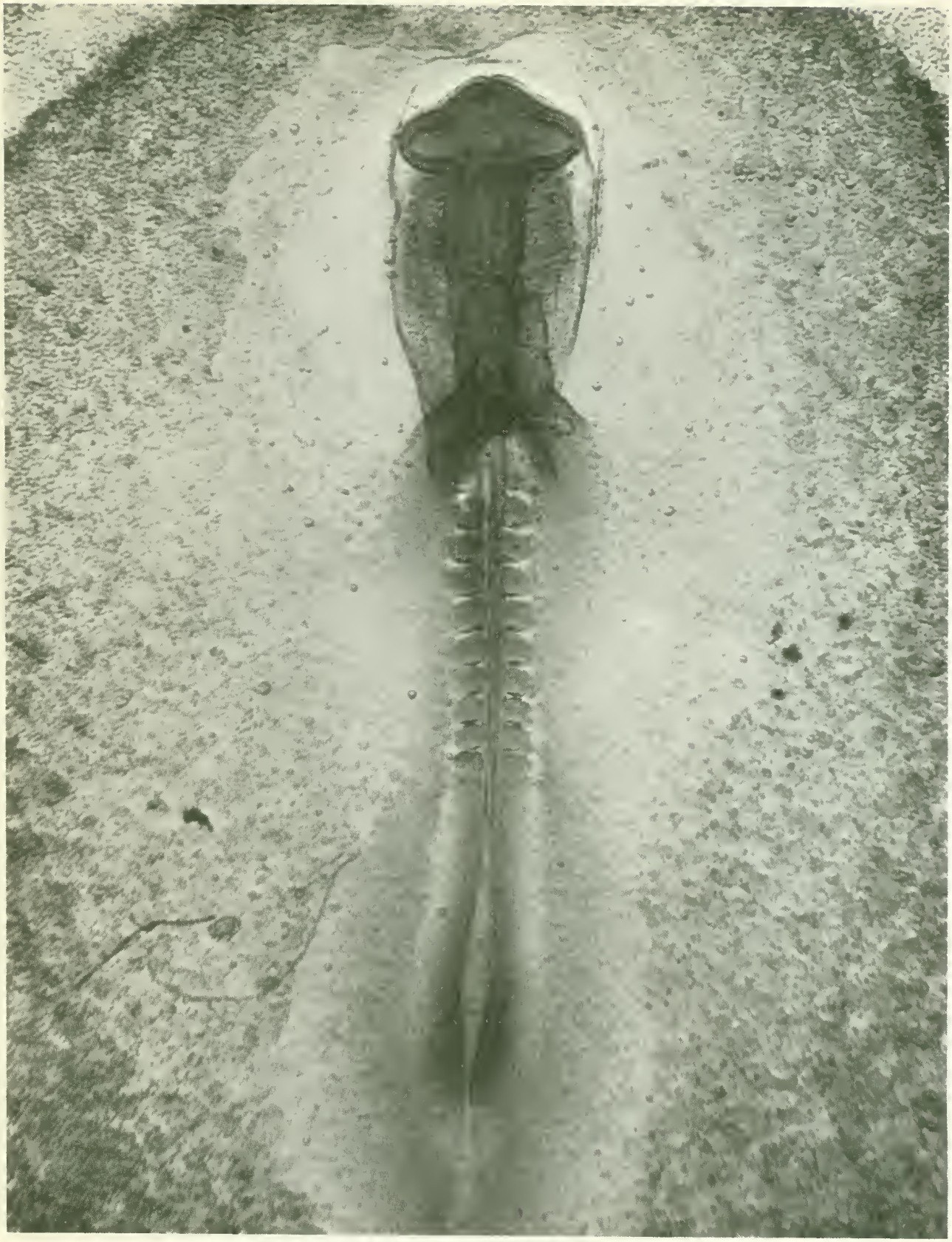


Drawing of specimen 29

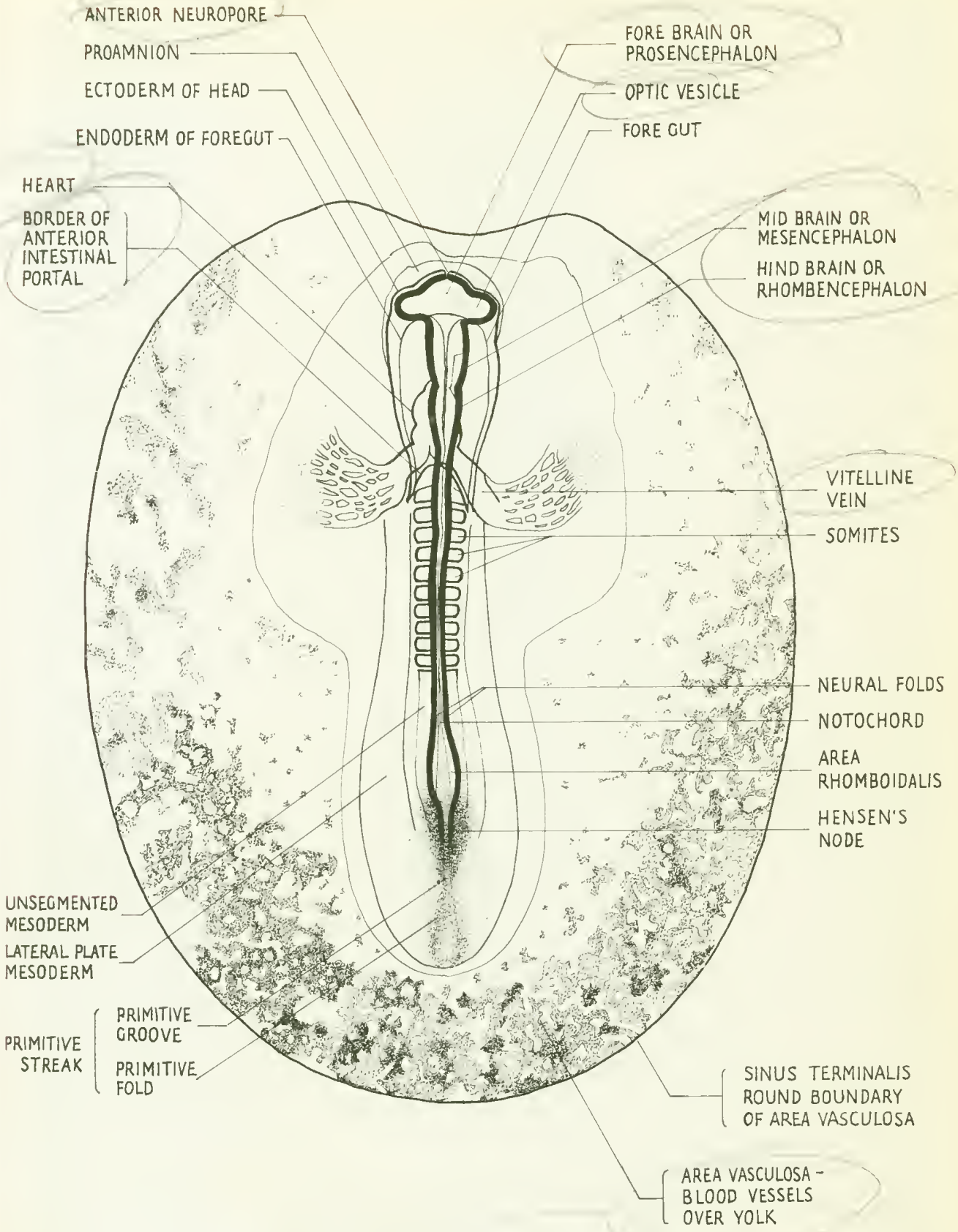
30. **Chick:** blastoderm, 6-somite, E. *mag.* 40×



Drawing of specimen 30



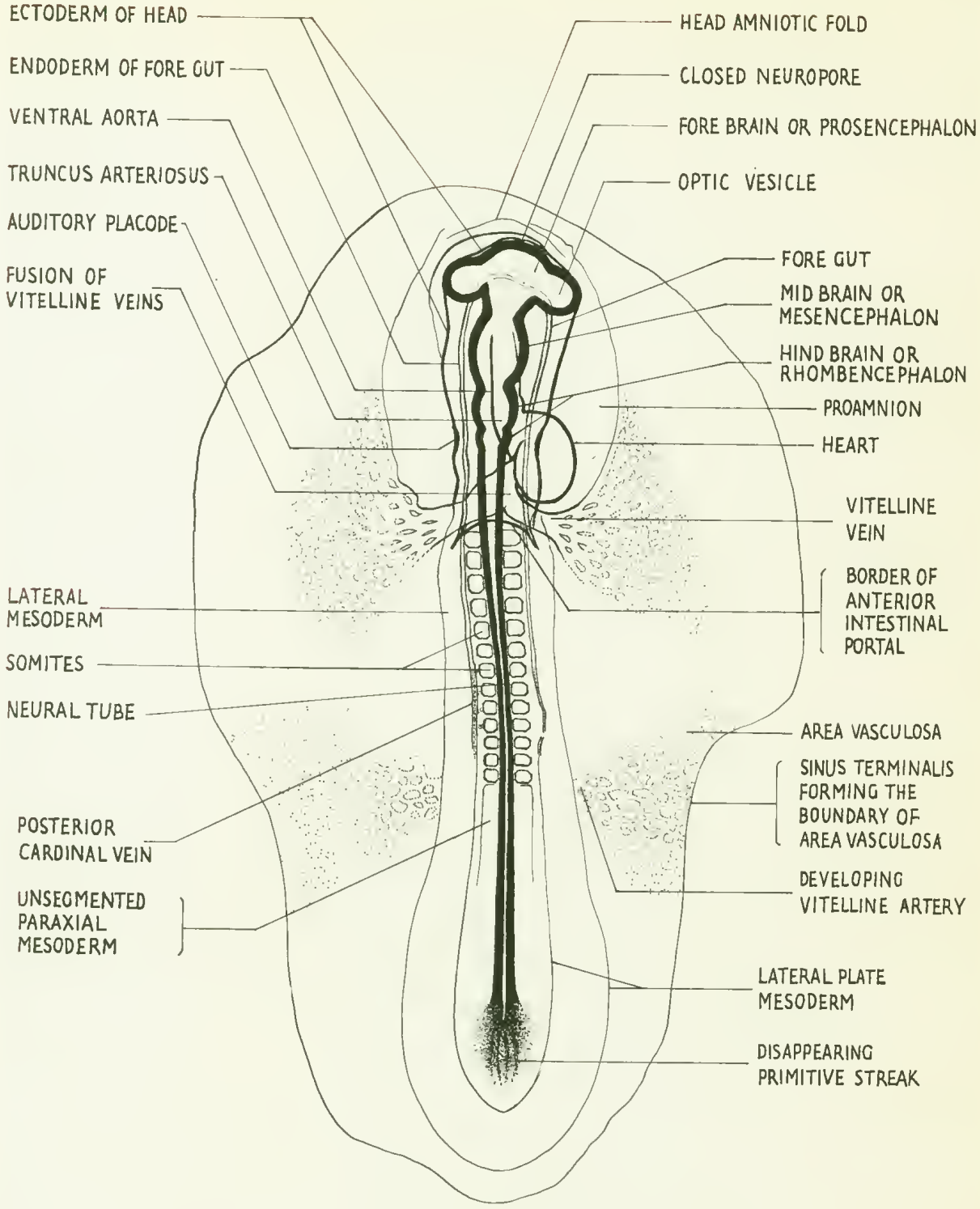
31. **Chick:** blastoderm, 10-somite, E. *mag.* 45×



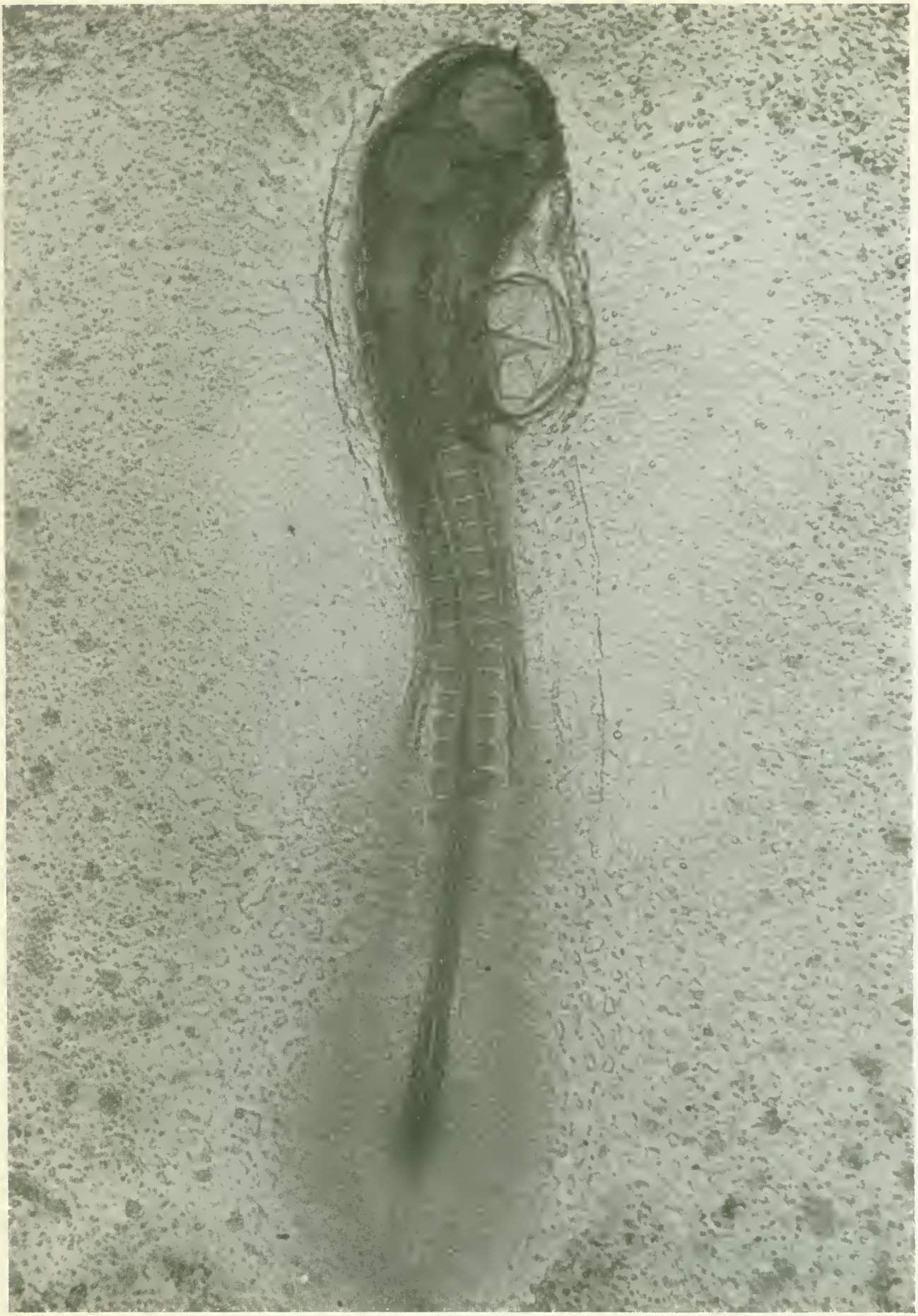
Drawing of specimen 31

(Drawn from ventral aspect; photograph is of dorsal aspect)

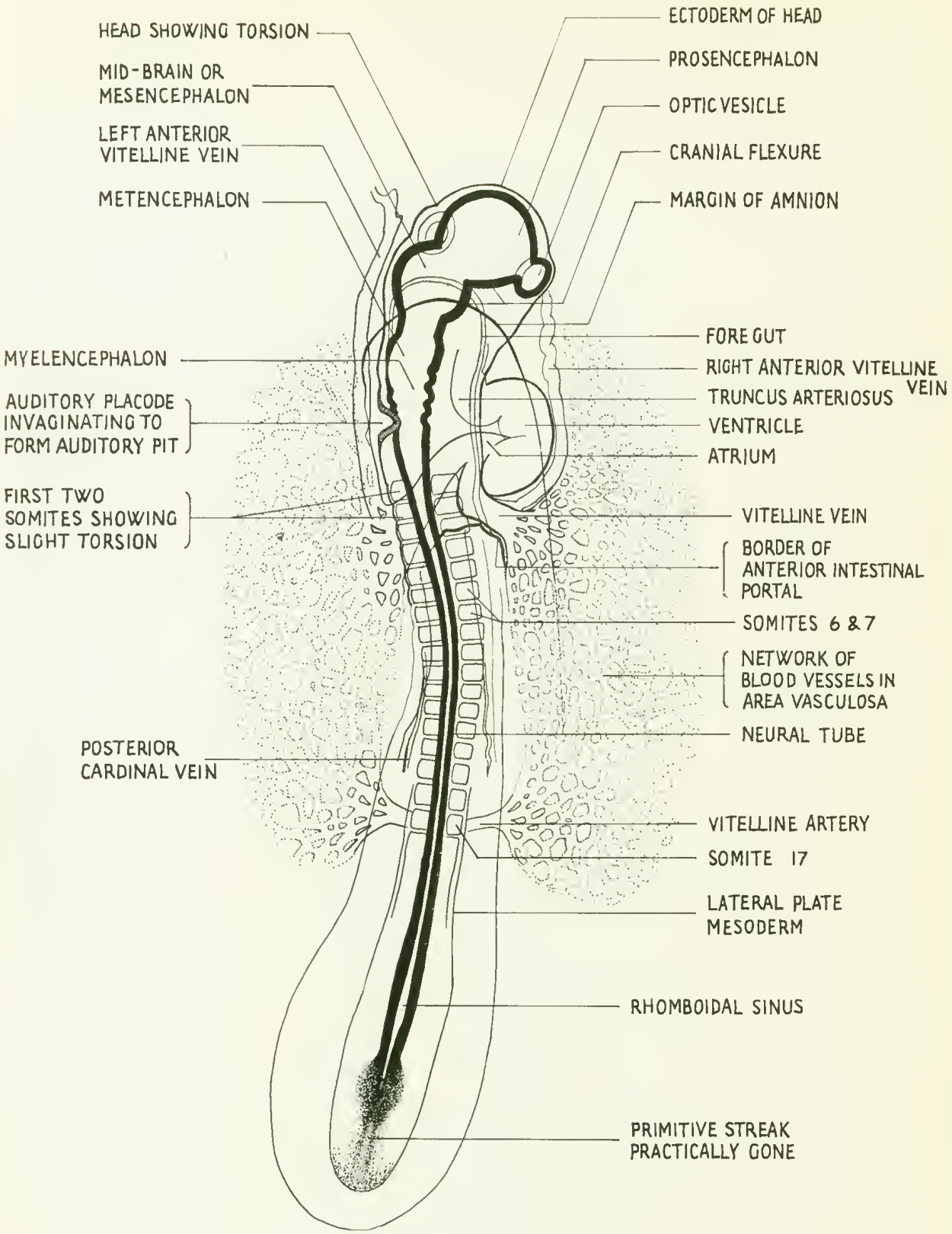
32. **Chick:** blastoderm, 13-somite, E. *mag.* 35×



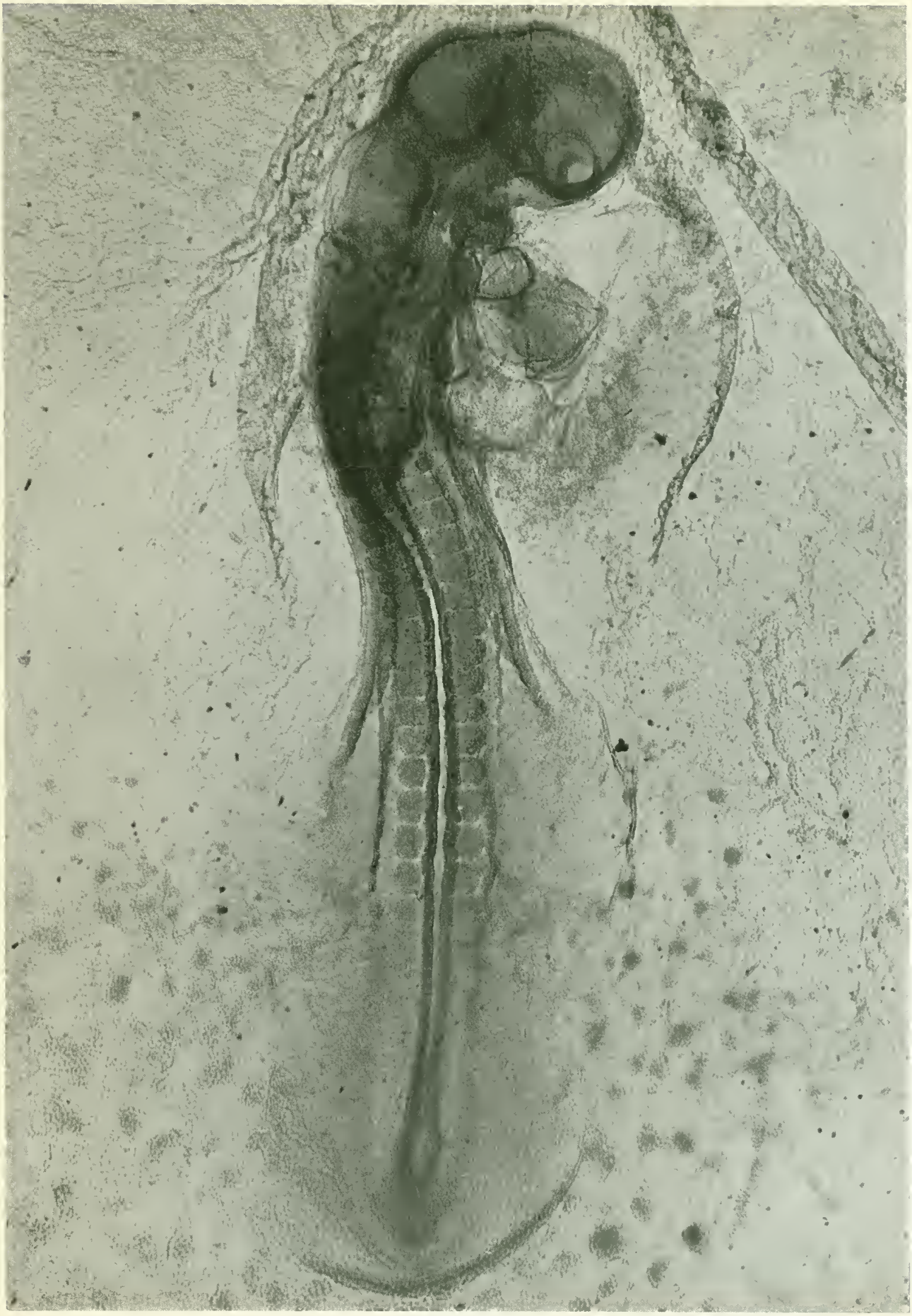
Drawing of specimen 32

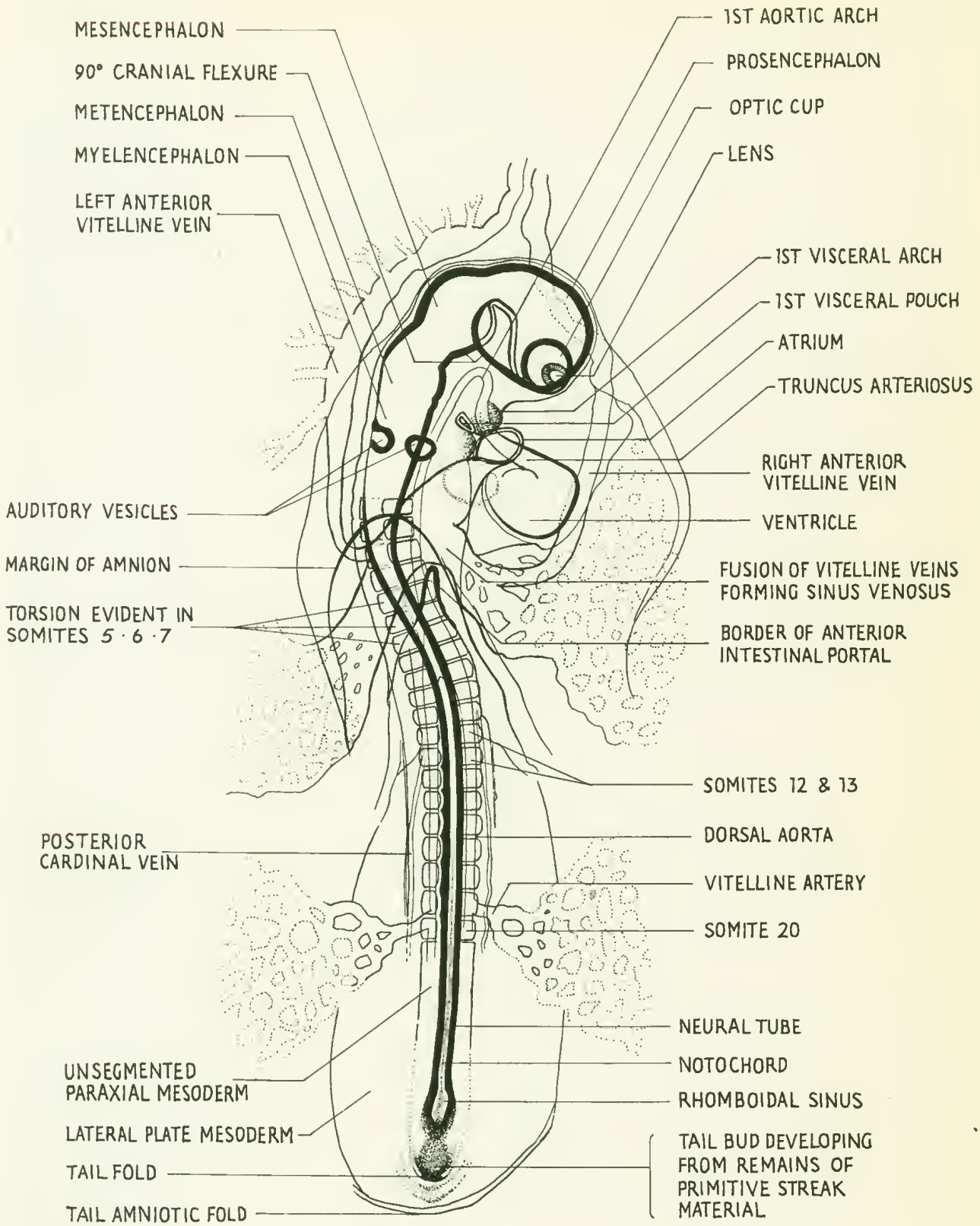


33. **Chick:** blastoderm, 17-somite, E. *mag. 30*×



Drawing of specimen 33

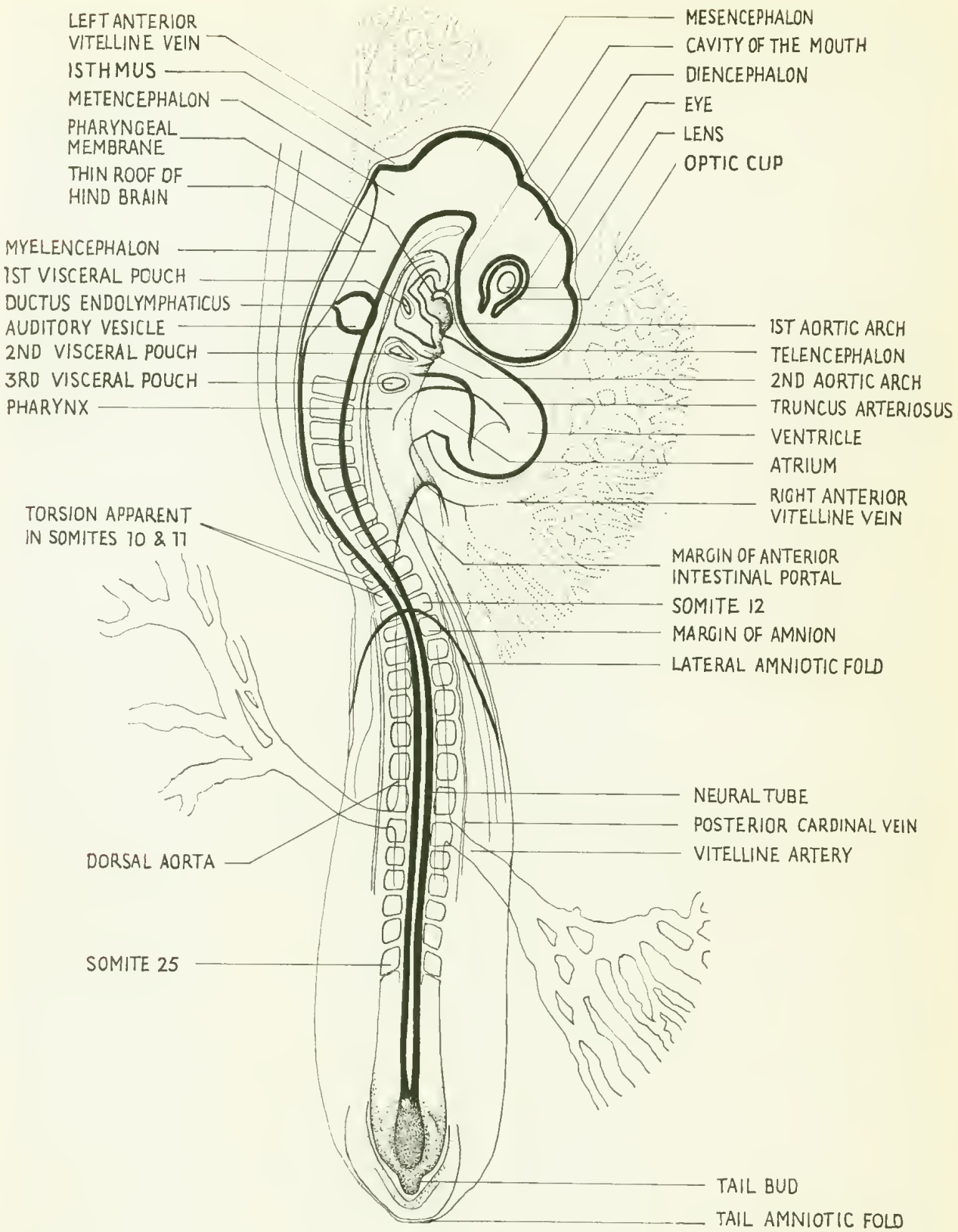




Drawing of specimen 34

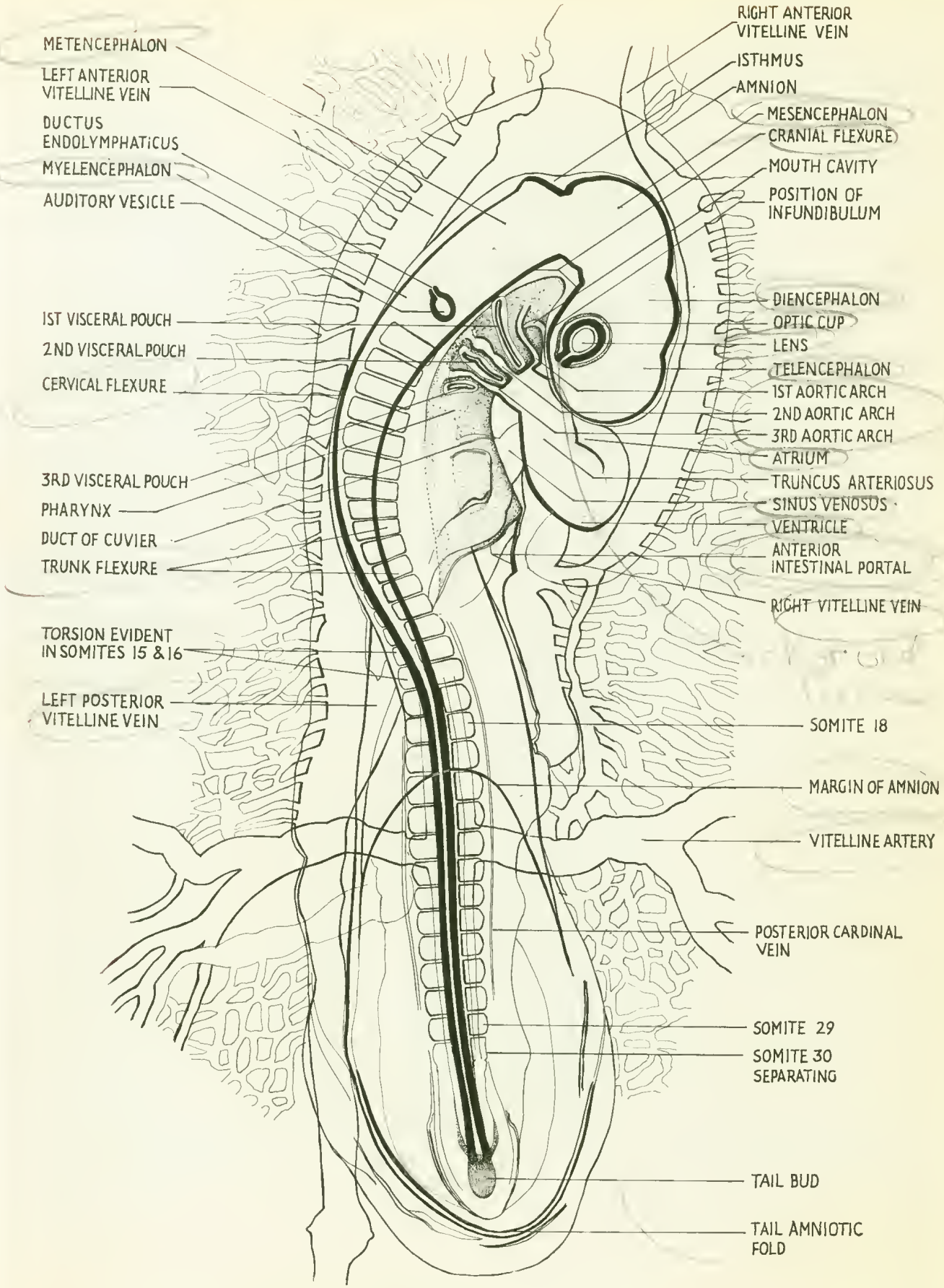
(*Left*) 34. **Chick:** blastoderm, 20-somite, E. *mag. 40*×

35. **Chick:** blastoderm, 25-somite, E. *mag.* 45×



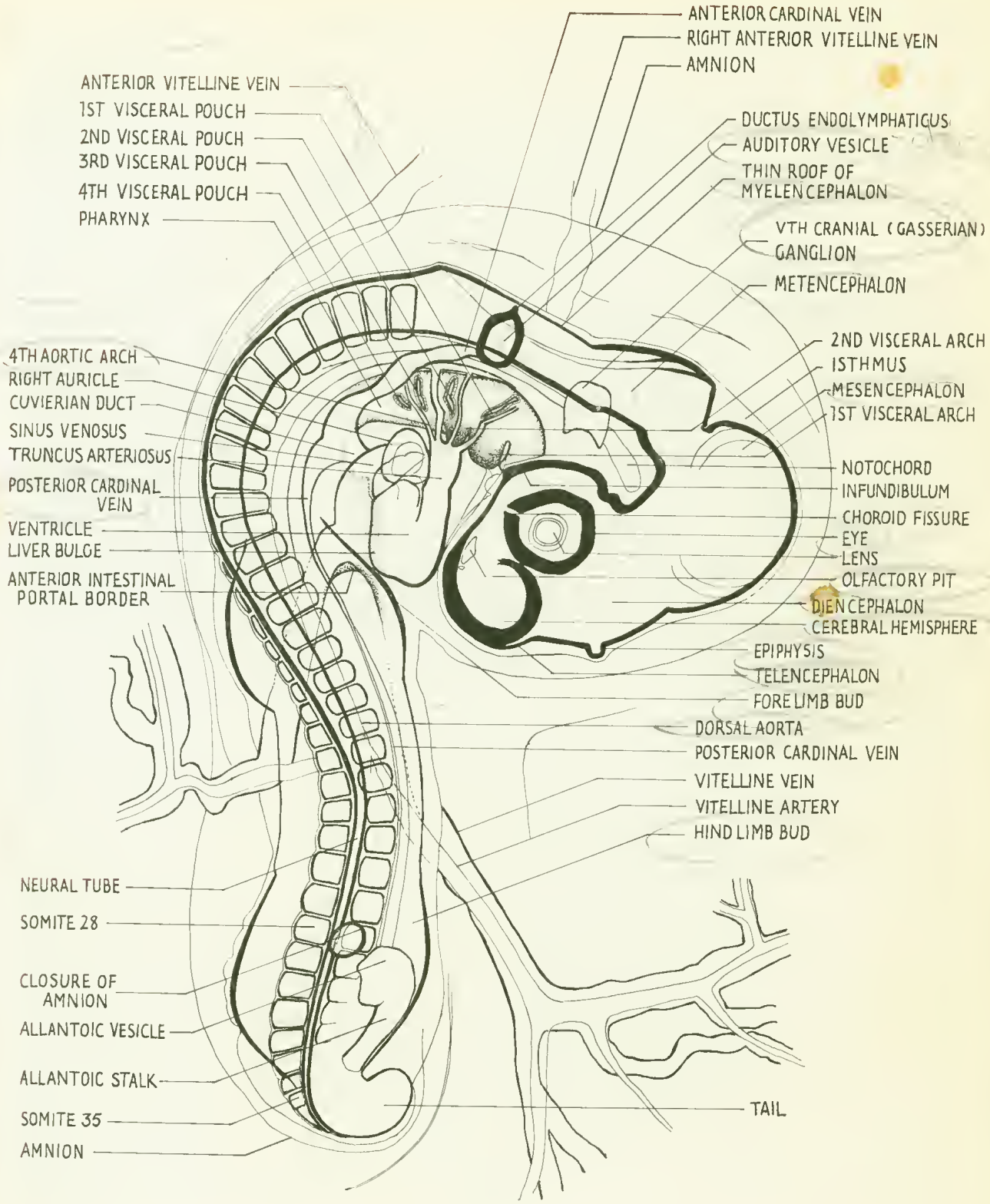
Drawing of specimen 35

36. **Chick:** blastoderm, 30-somite, E. *mag.* 25×



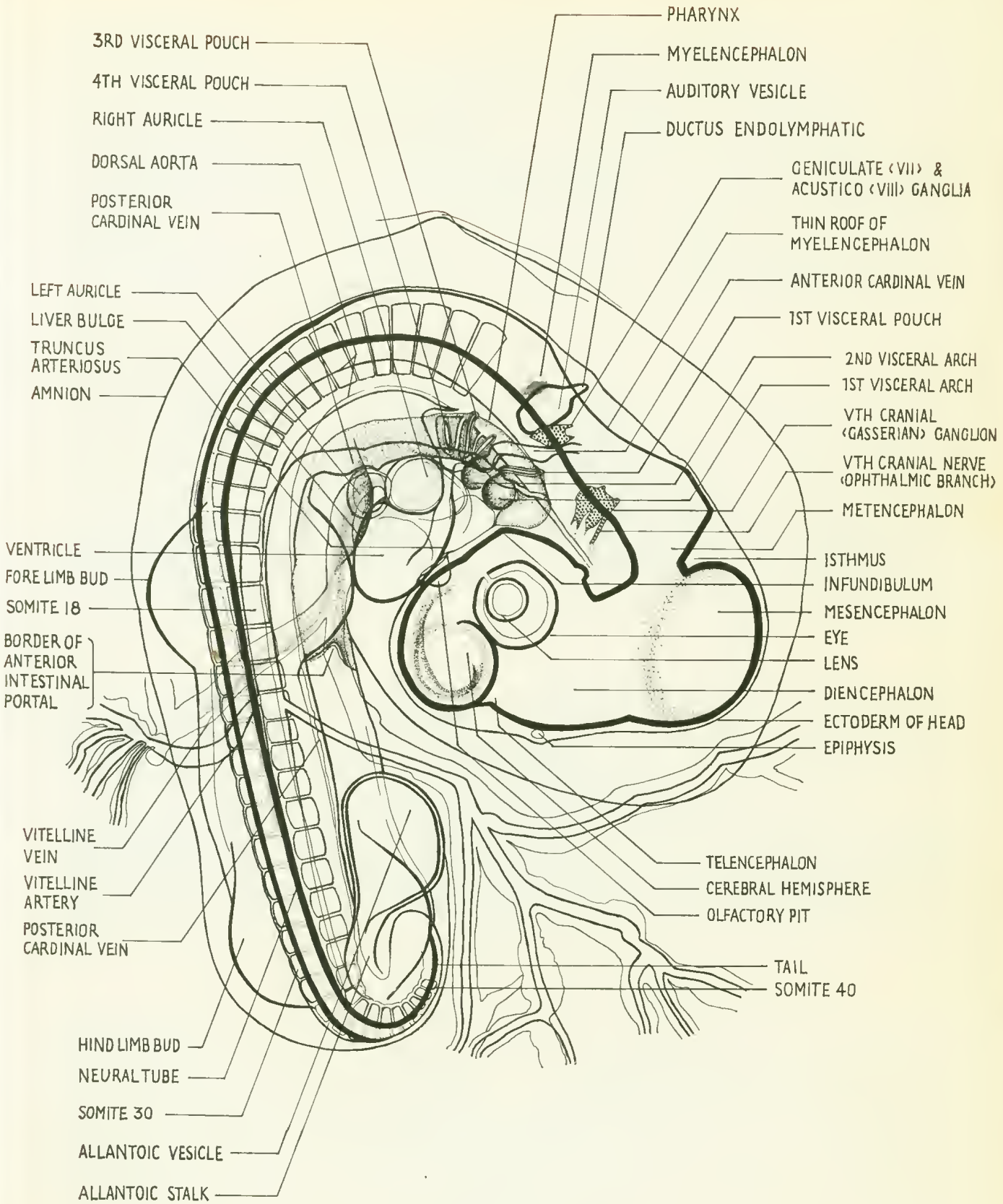
Drawing of specimen 36

37. **Chick:** blastoderm, 35-somite, E. *mag.* 30×

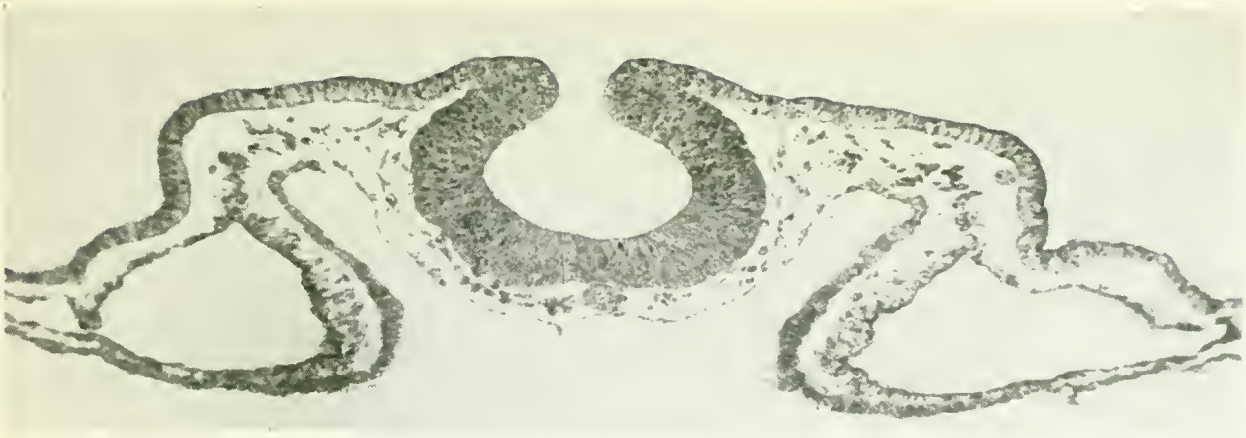


Drawing of specimen 37

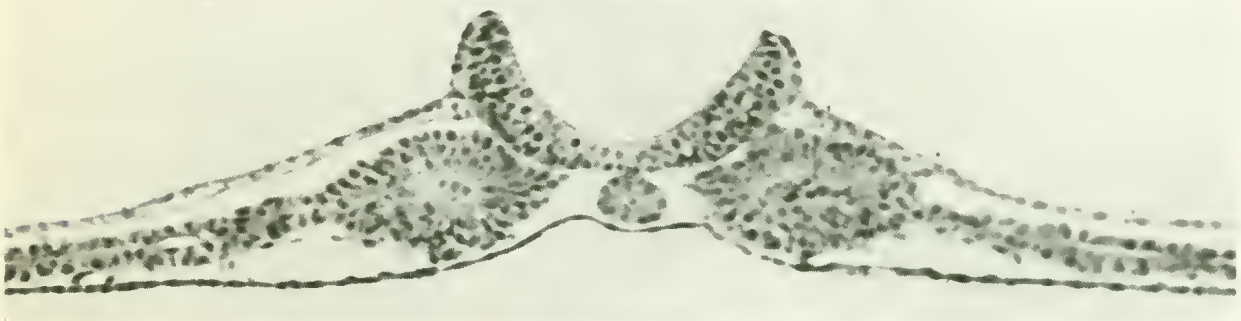
38. **Chick:** blastoderm, 40-somite, E. *mag. 30×*



Drawing of specimen 38

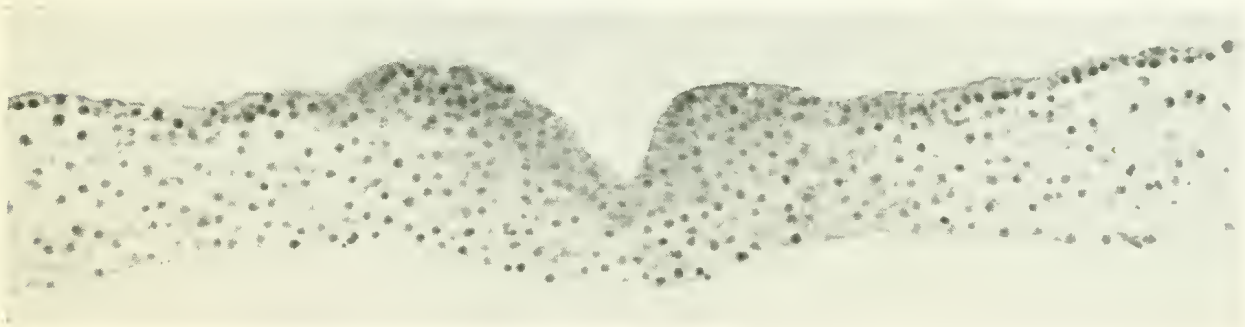


39. **Chick:** 6-somite stage, head region, T.S. *mag. 140×*

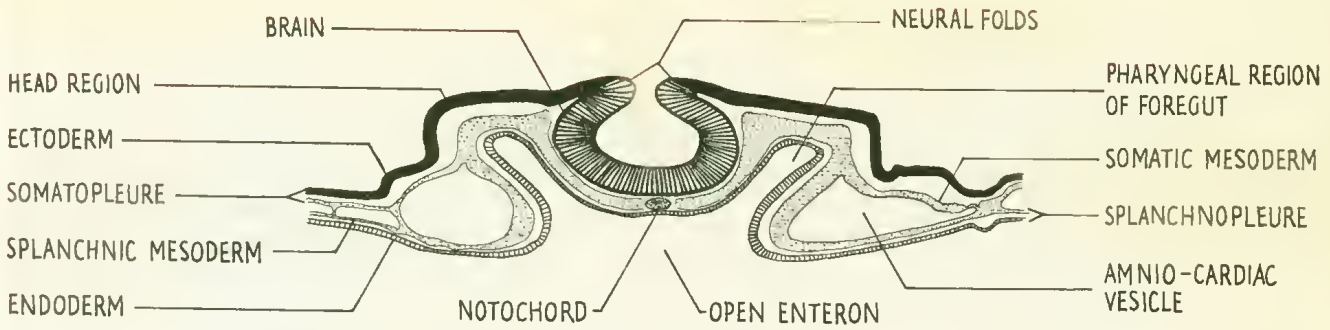


40. **Chick:** 6-somite stage, somitic region, T.S. *mag. 200×*

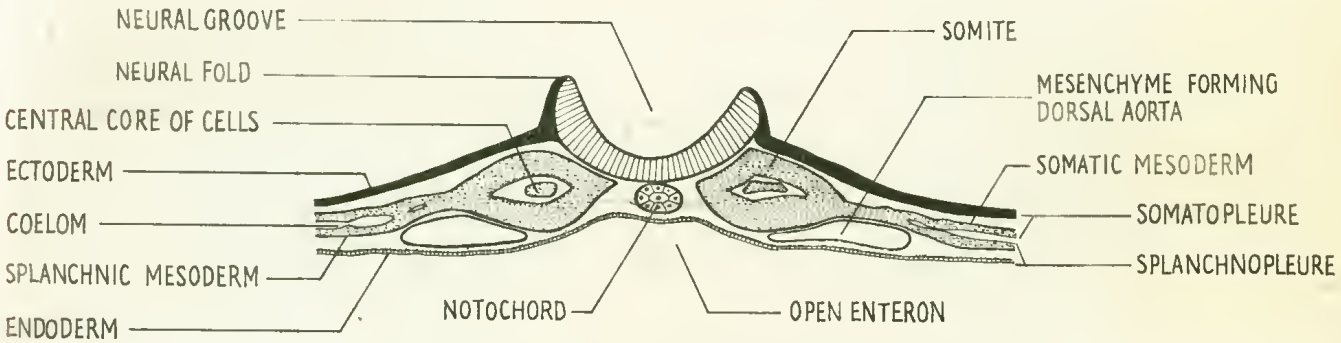
41. **Chick:** 6-somite stage, notochord, T.S. *mag. 225×*



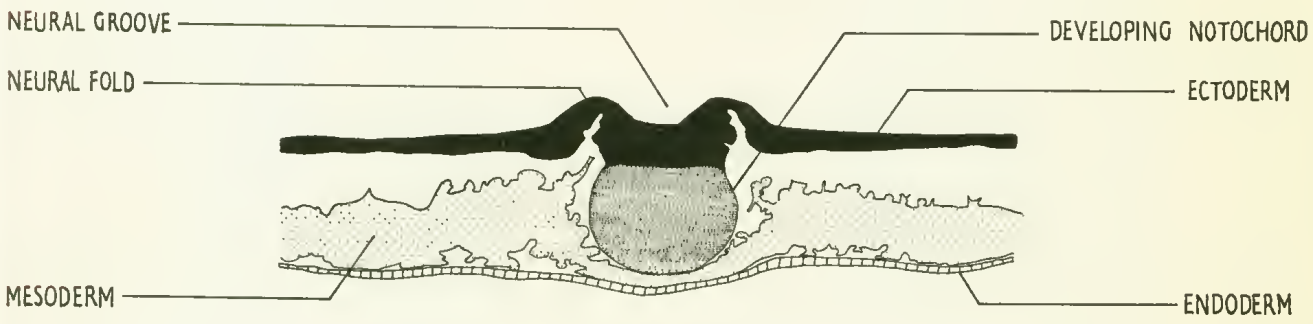
42. **Chick:** 6-somite stage, primitive streak, T.S. *mag. 200×*



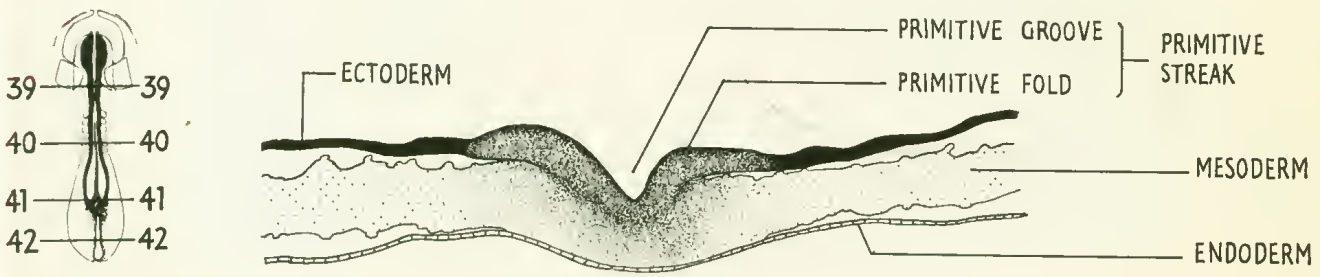
Drawing of specimen 39



Drawing of specimen 40

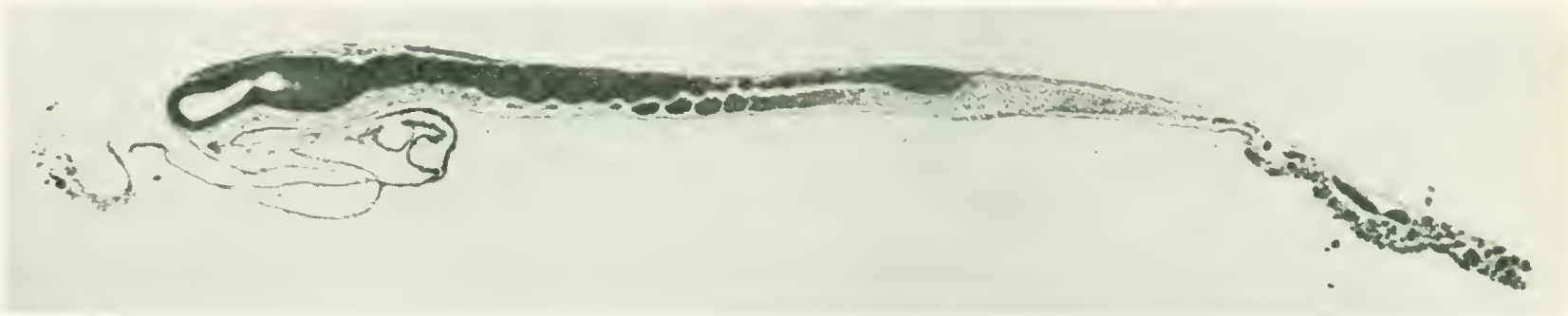


Drawing of specimen 41

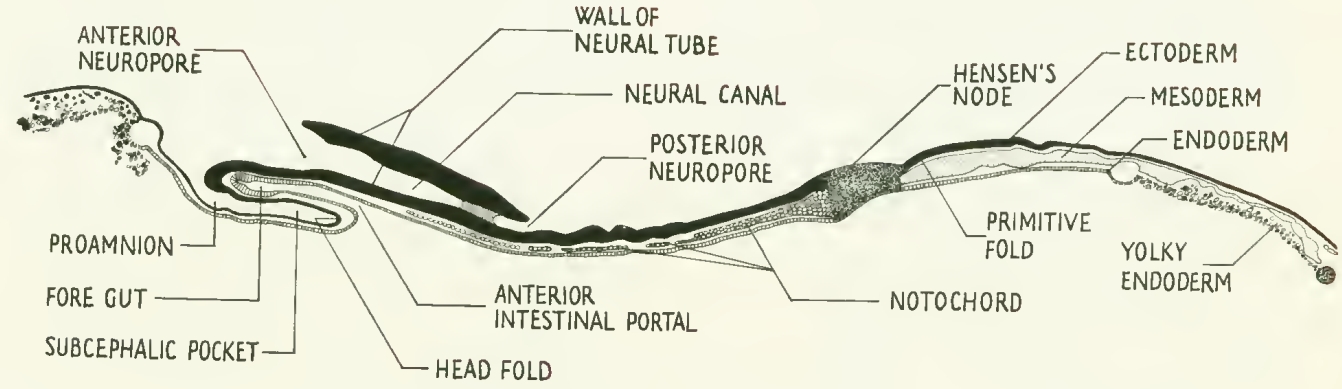


Drawing of specimen 42

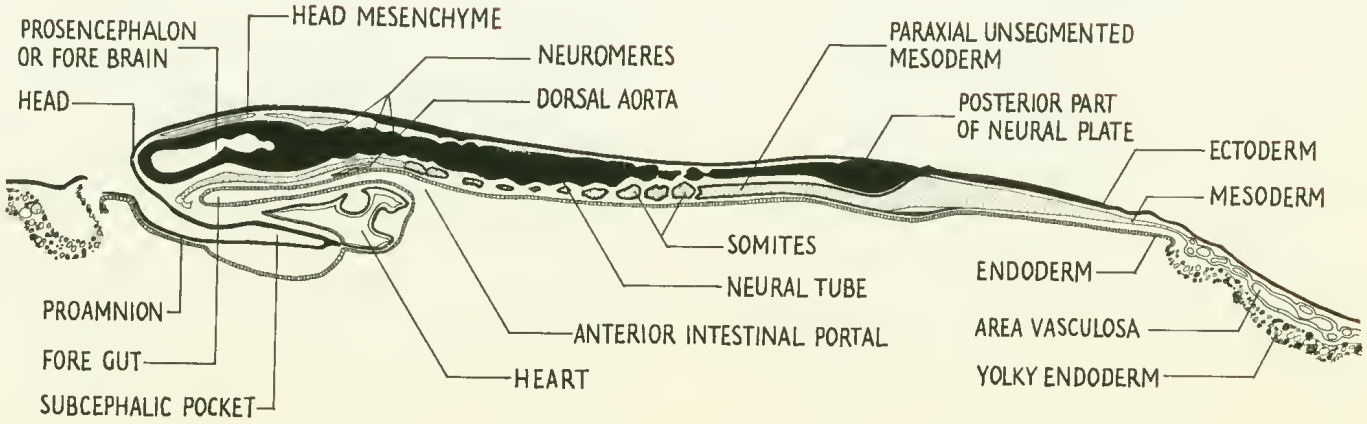
43. **Chick:** 6-somite stage, U.L.S. *mag.* 38×



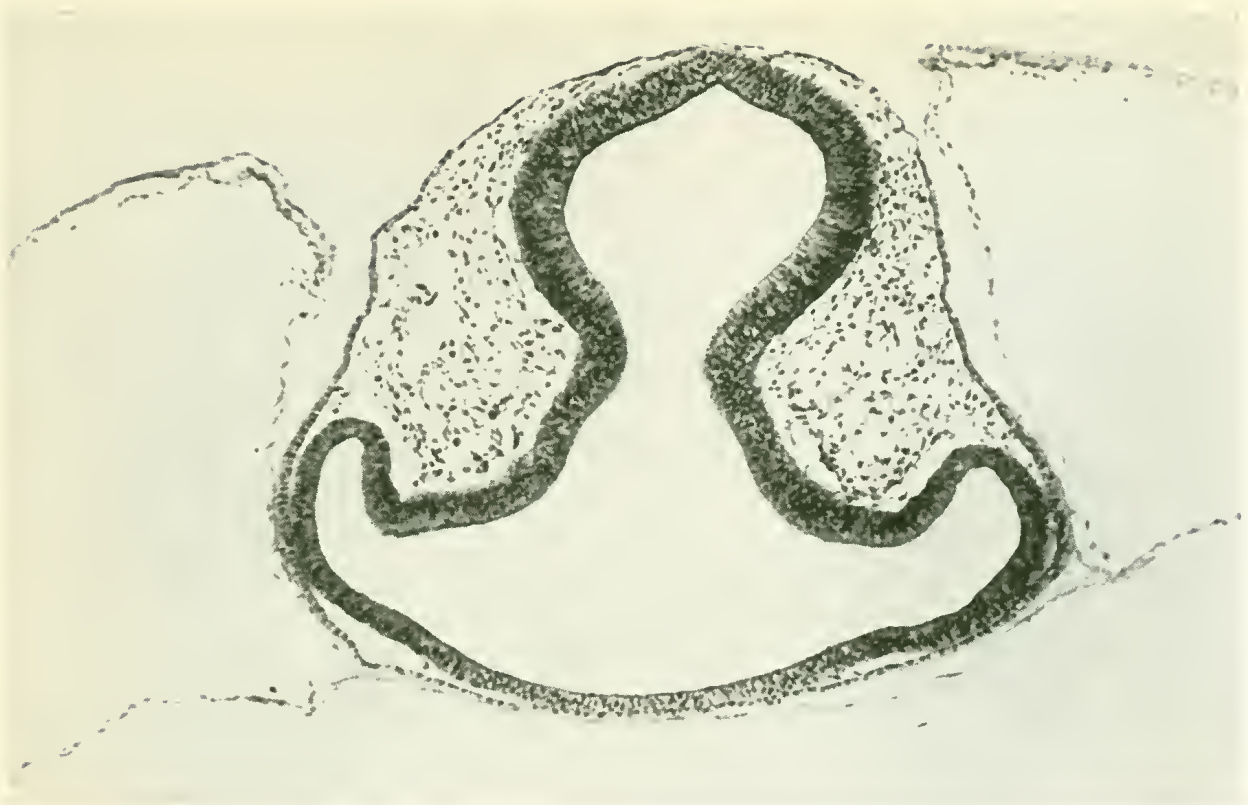
44. **Chick:** 10-somite stage, U.L.S. *mag.* 28×



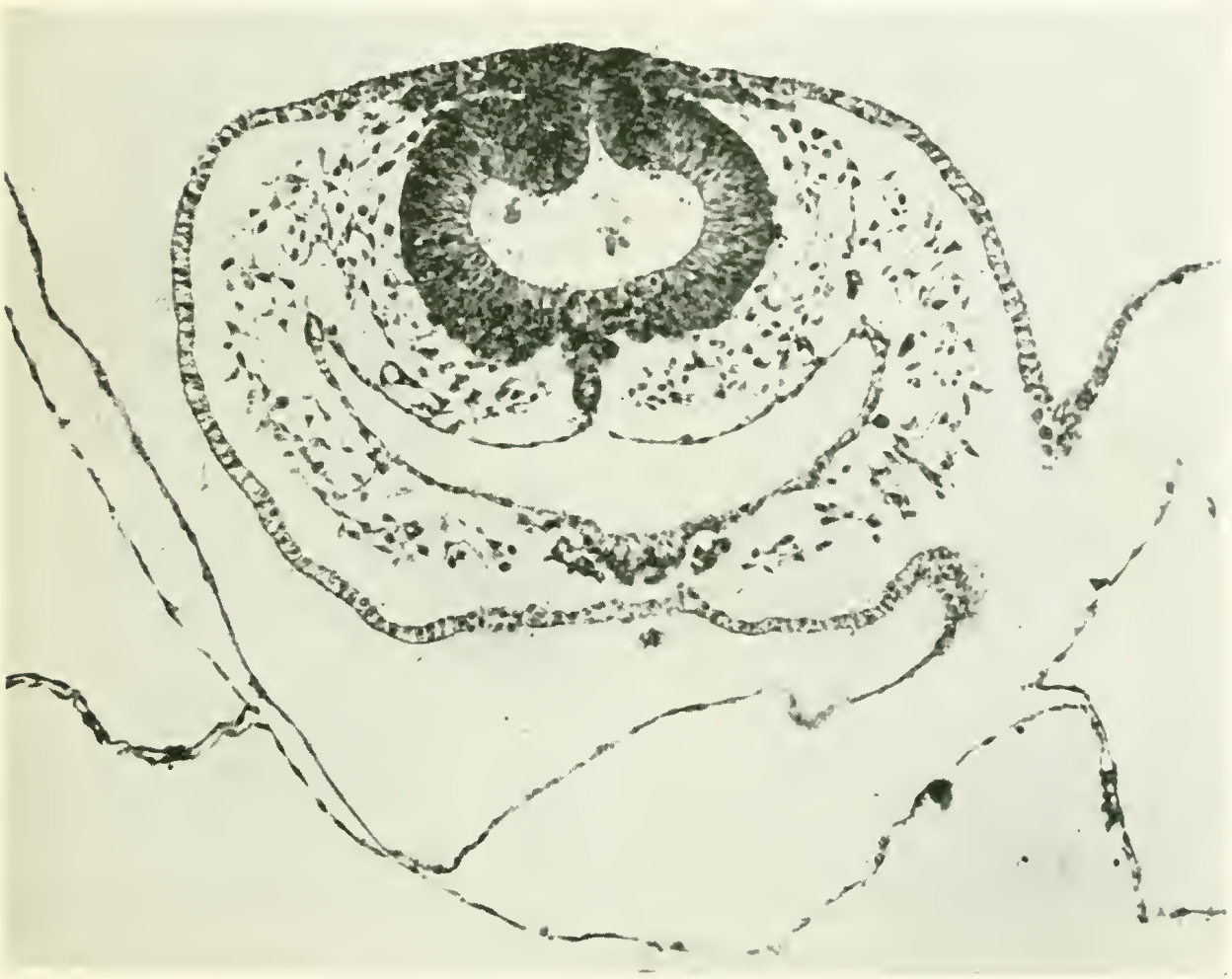
Drawing of specimen 43



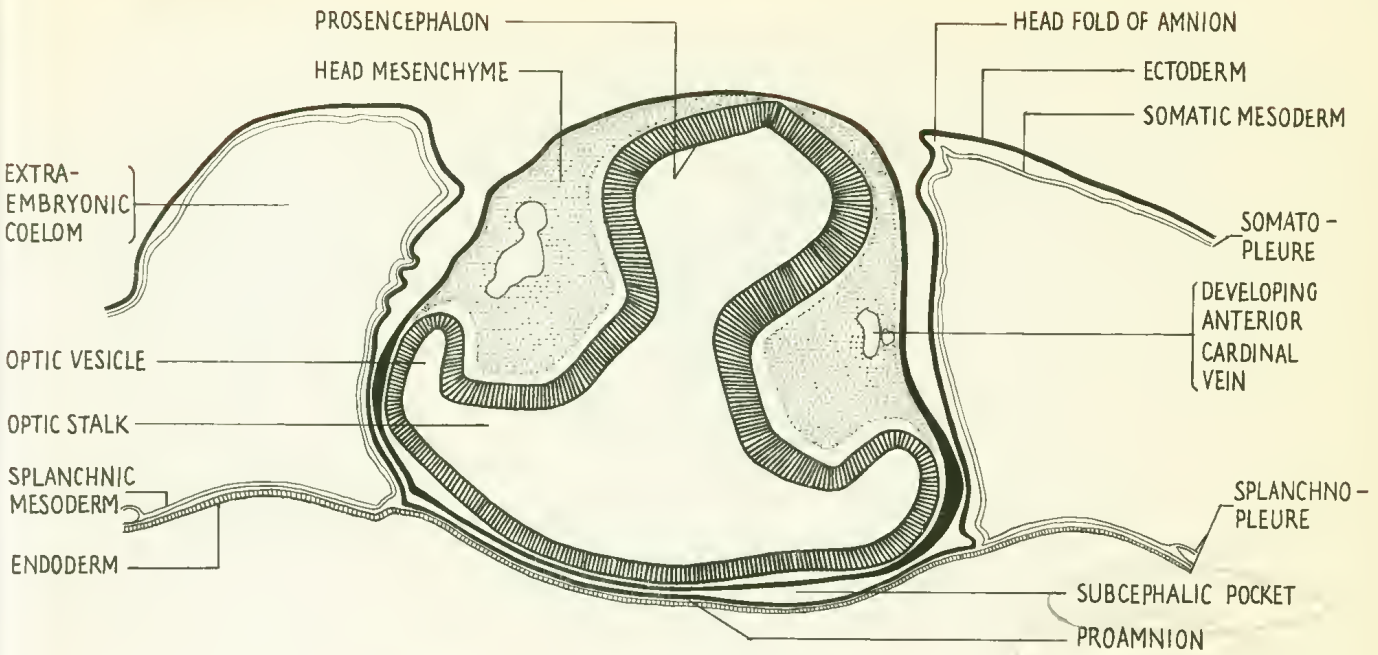
Drawing of specimen 44



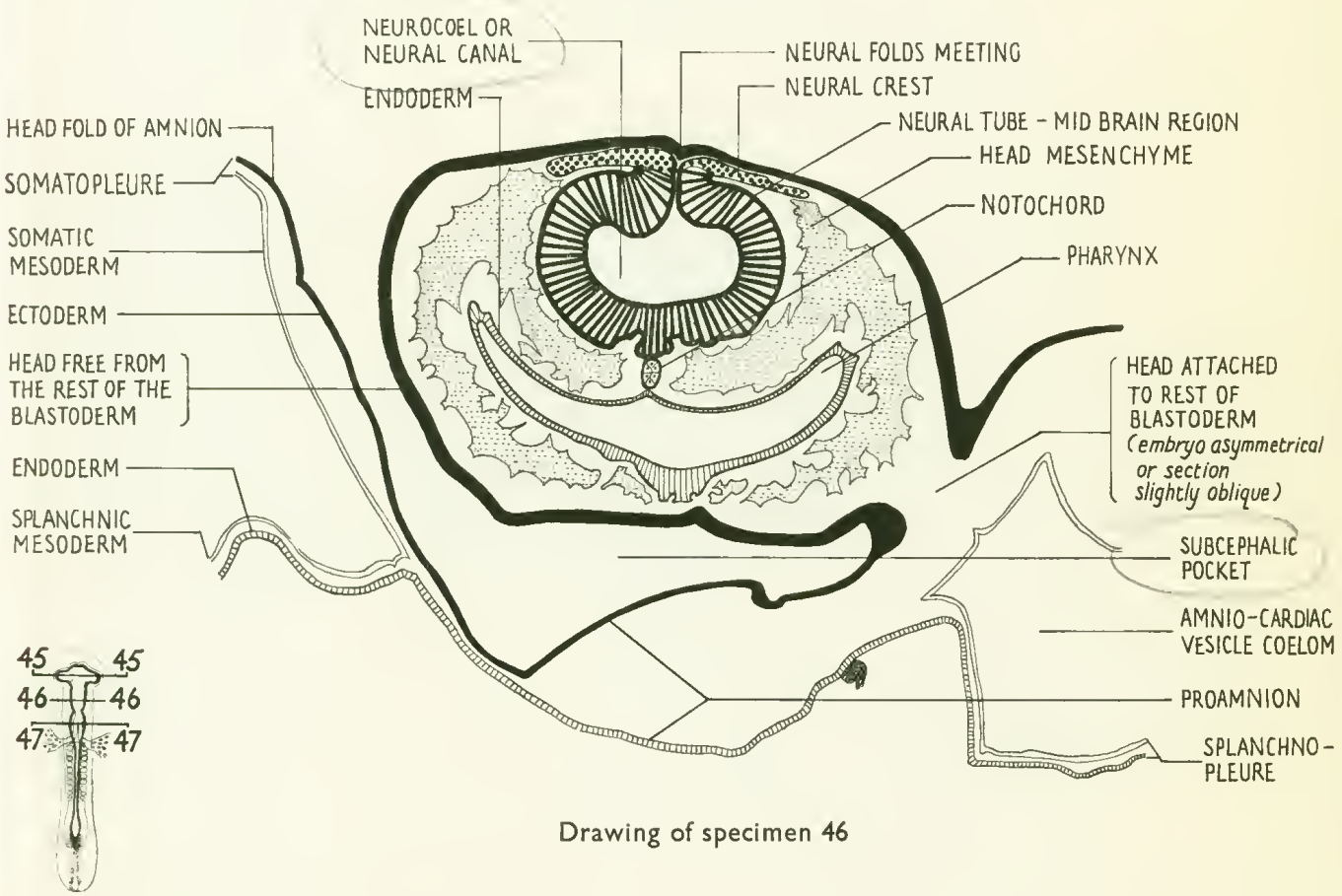
45. **Chick:** 10-somite stage, forebrain region, T.S. *mag. 100*×



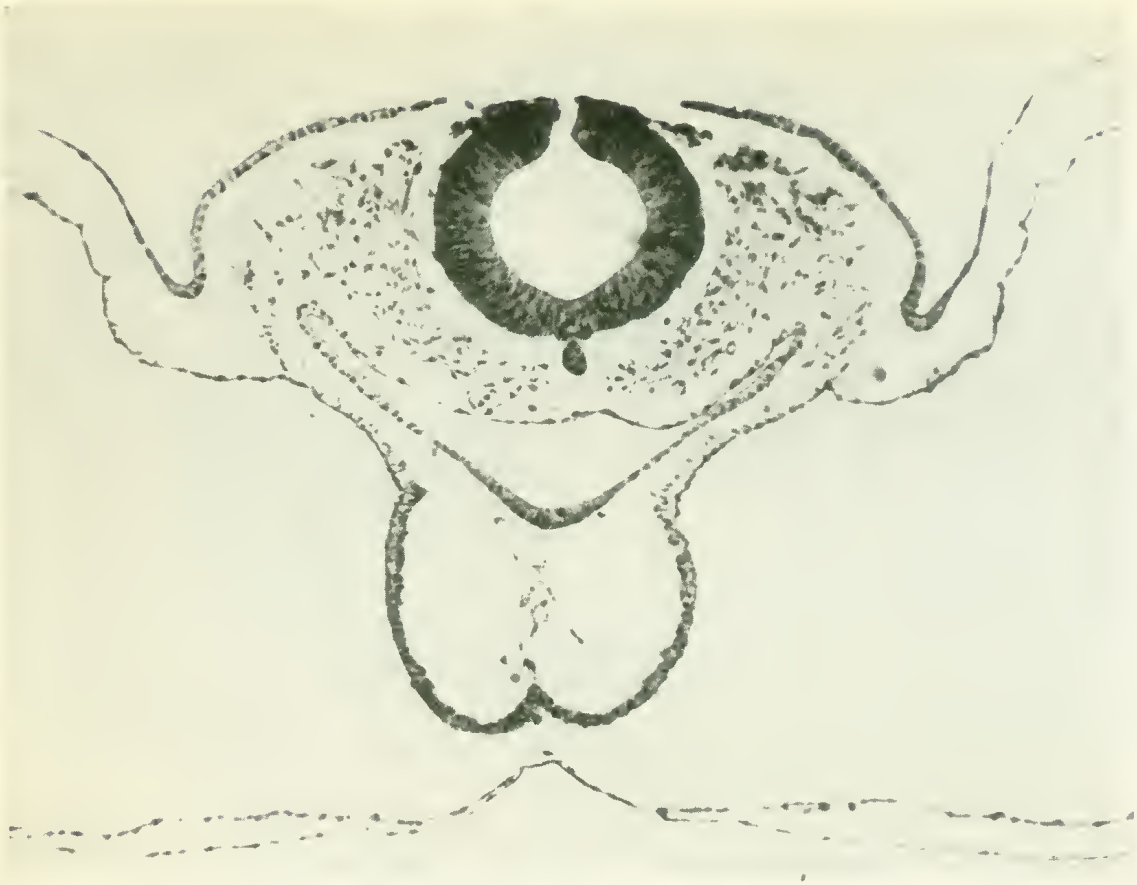
46. **Chick:** 10-somite stage, hindbrain region, T.S. *mag. 200*×



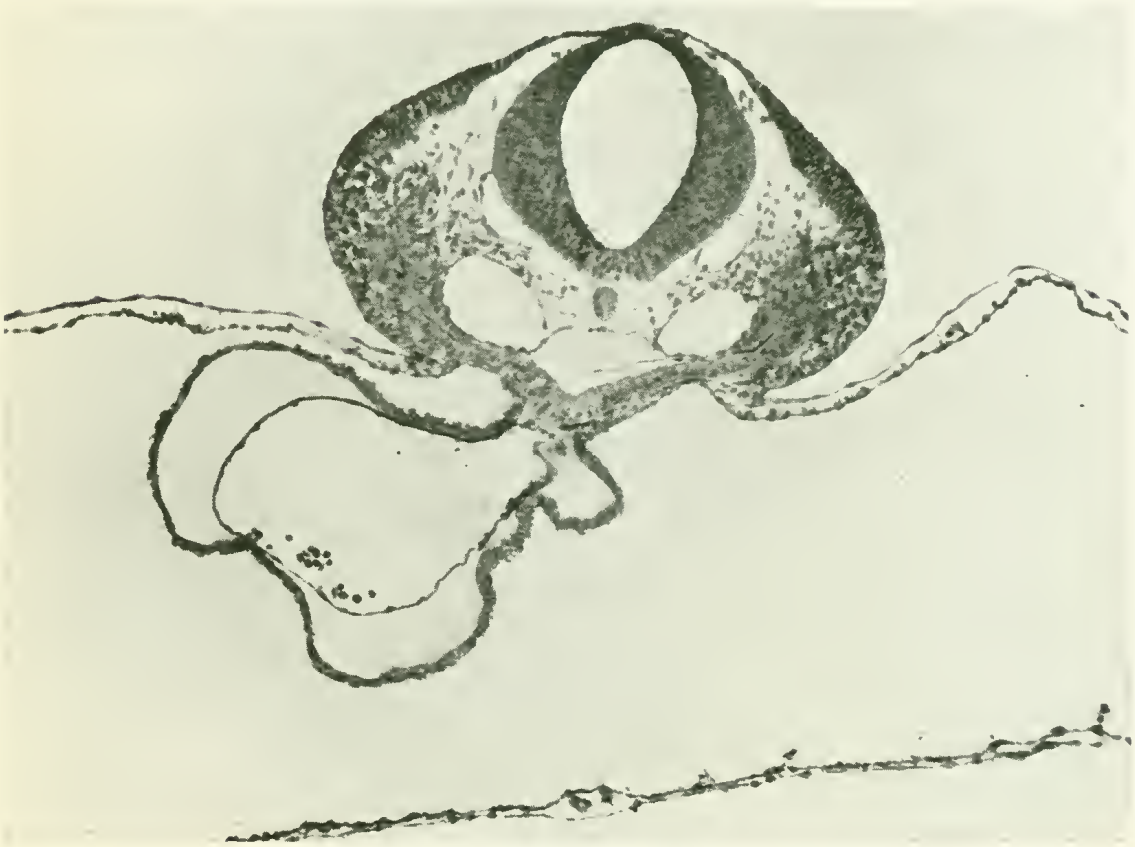
Drawing of specimen 45



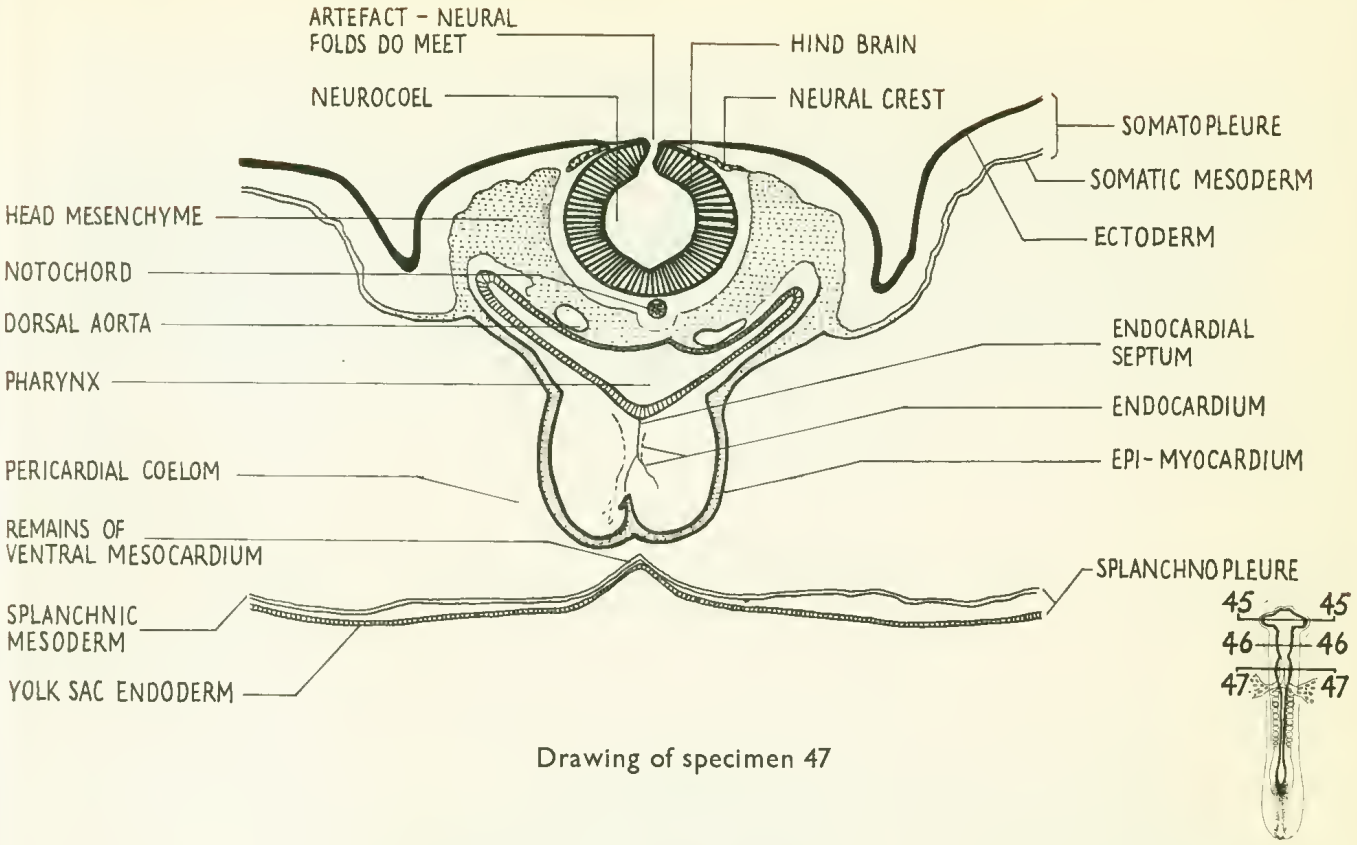
Drawing of specimen 46



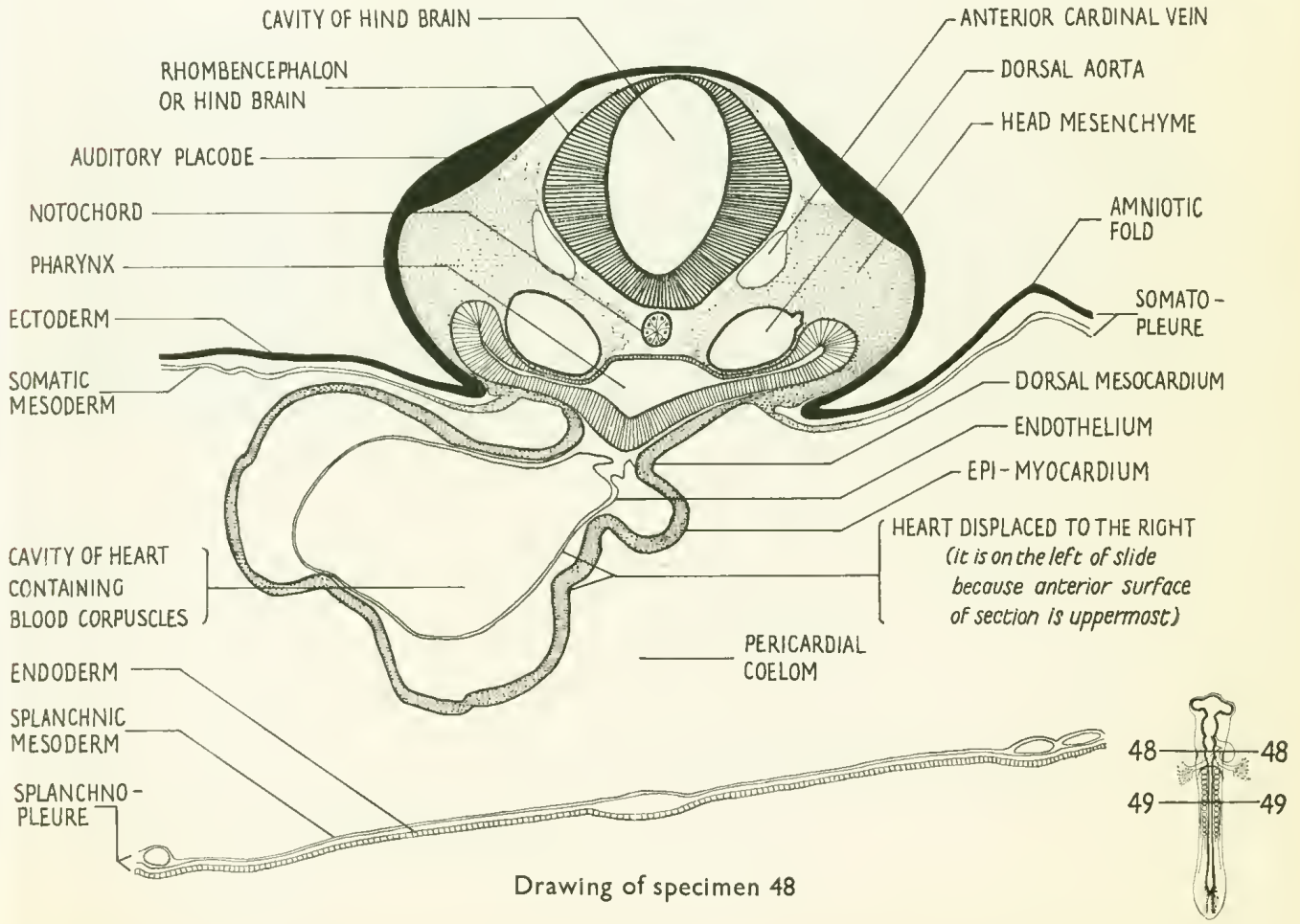
47. **Chick:** 10-somite stage, heart region, T.S. *mag. 150*×



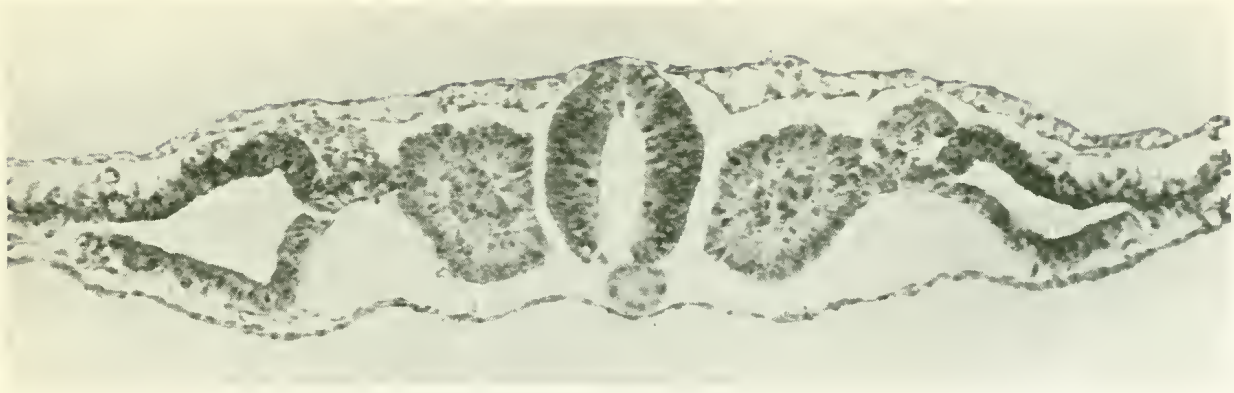
48. **Chick:** 13-somite stage, heart region, T.S. *mag. 150*×



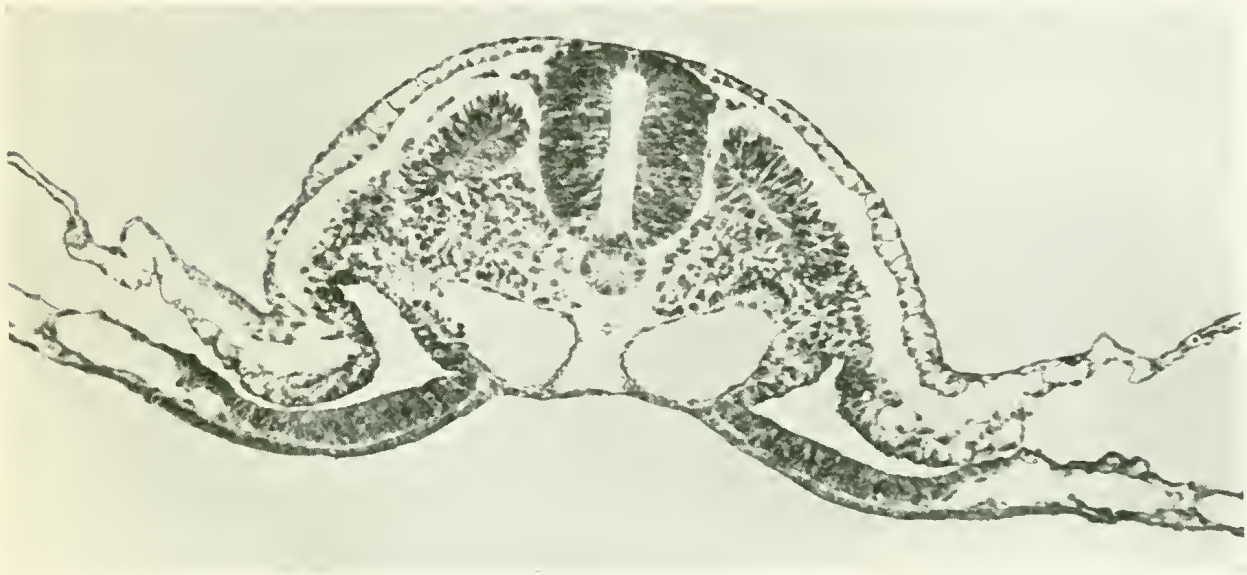
Drawing of specimen 47



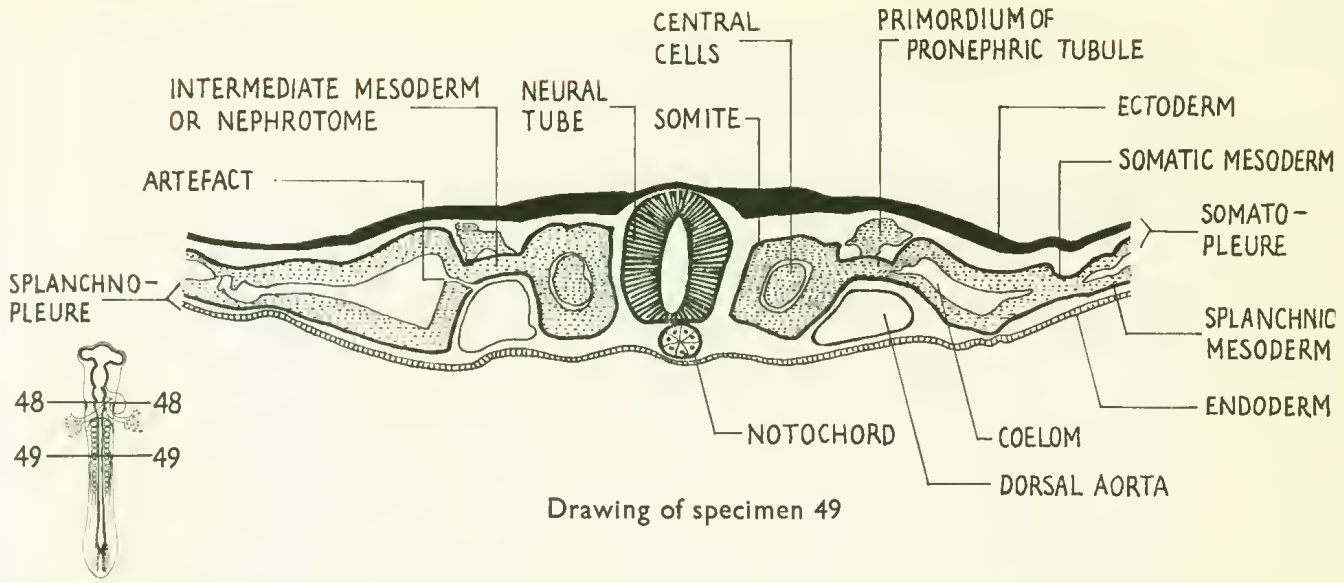
Drawing of specimen 48



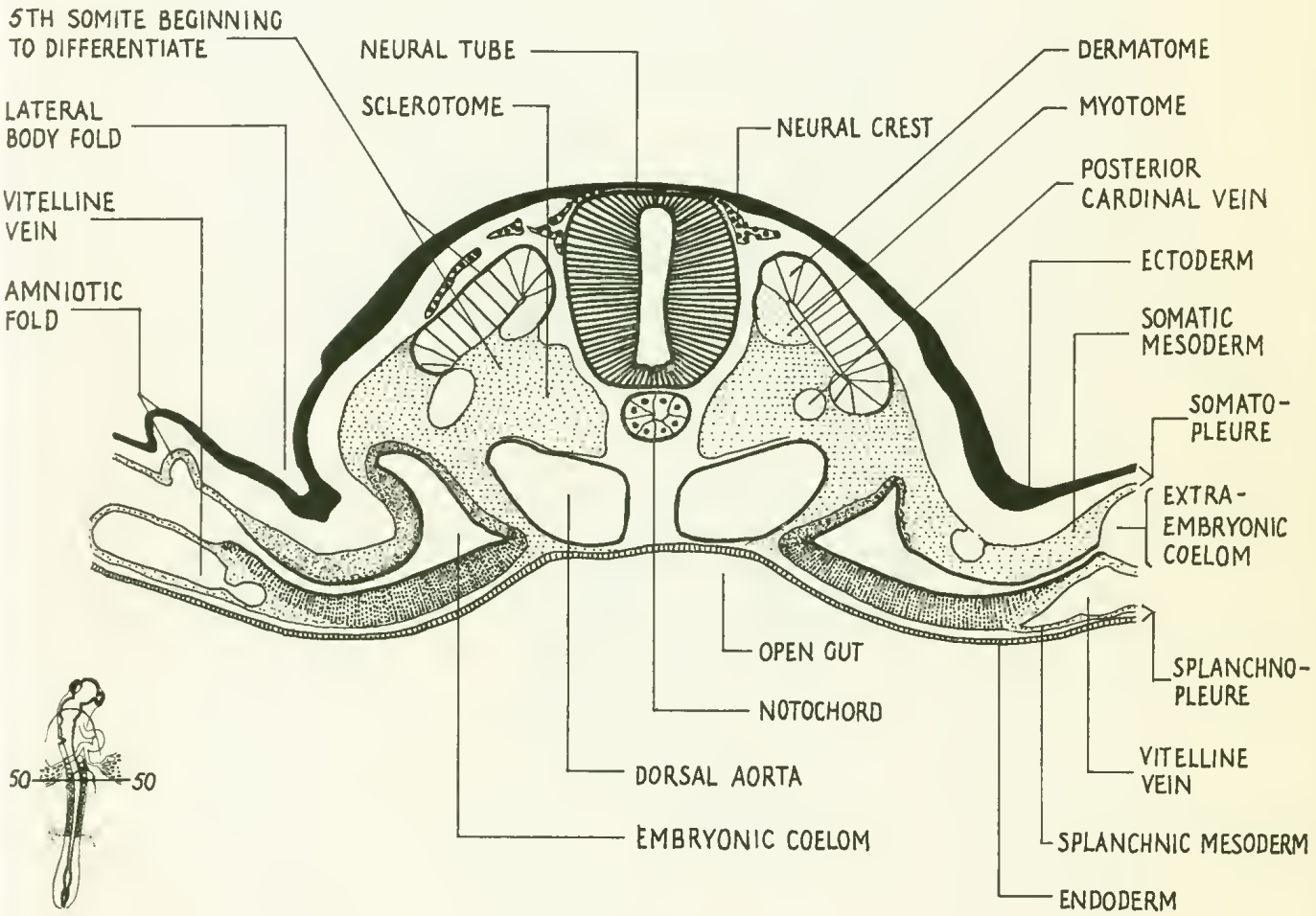
49. **Chick:** 13-somite stage, posterior trunk region, T.S. *mag. 175*×



50. **Chick:** 17-somite stage, trunk region, T.S. *mag. 150*×

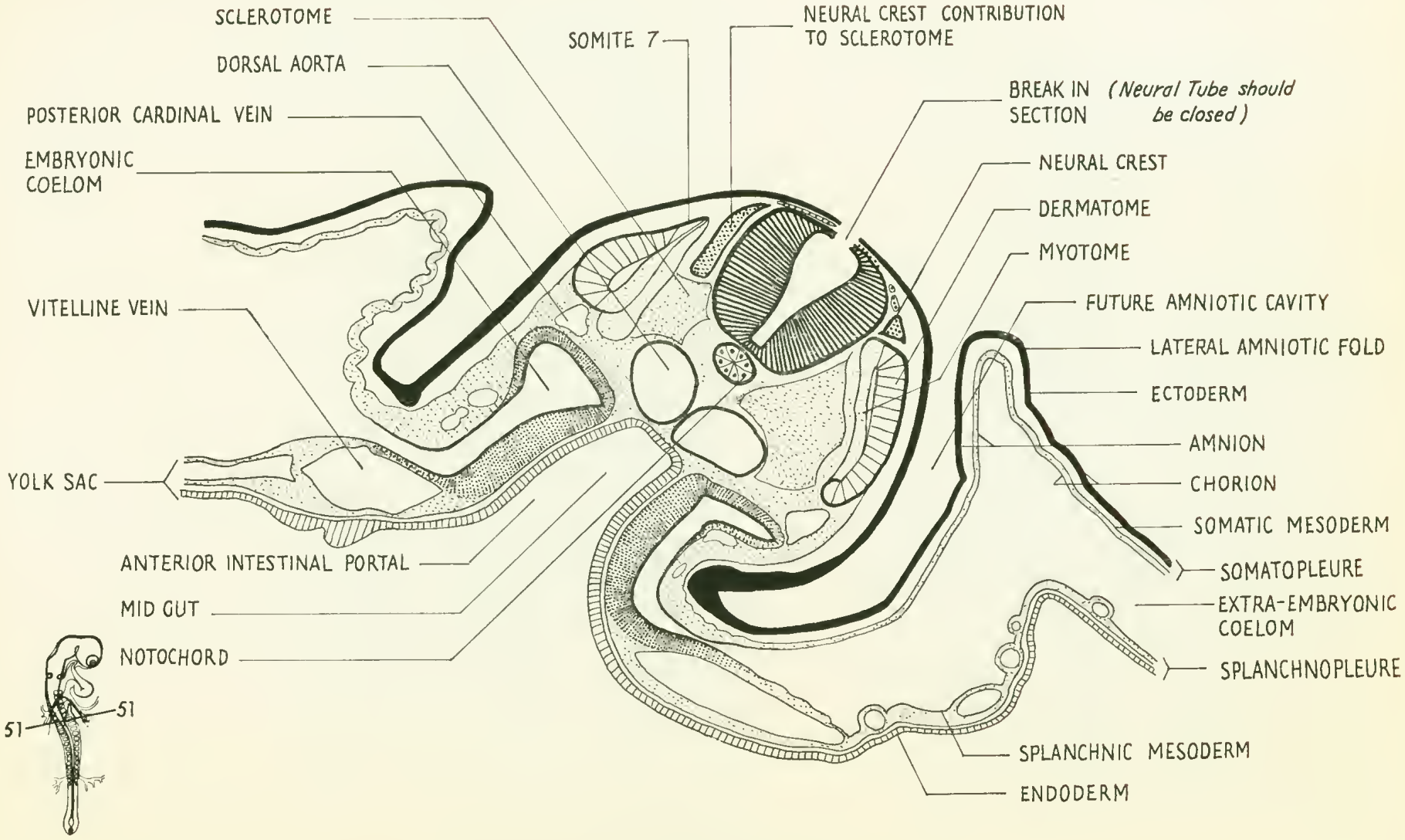


Drawing of specimen 49

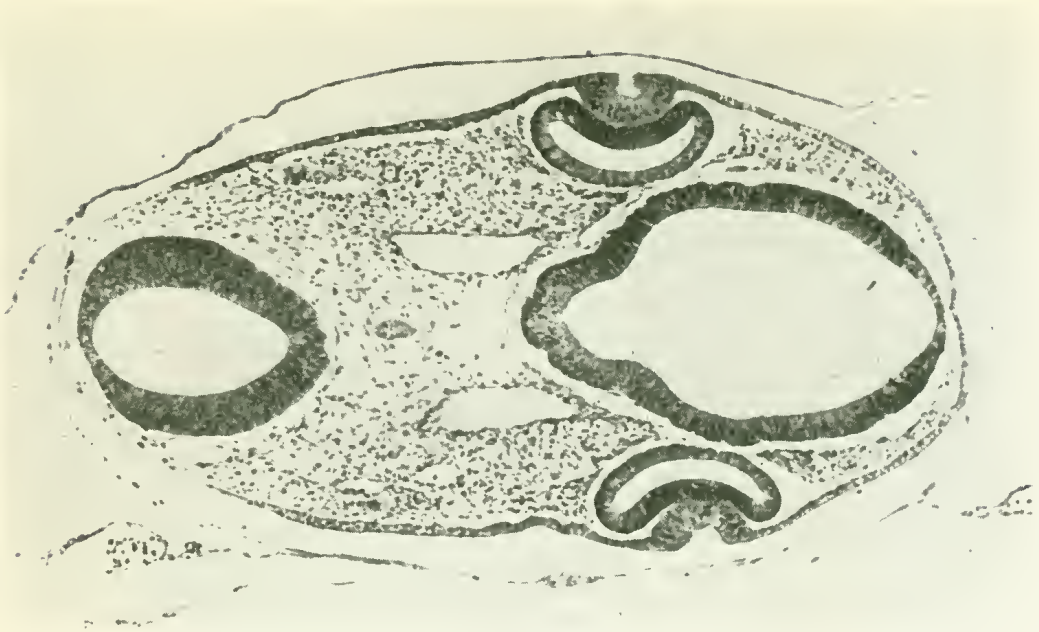


Drawing of specimen 50

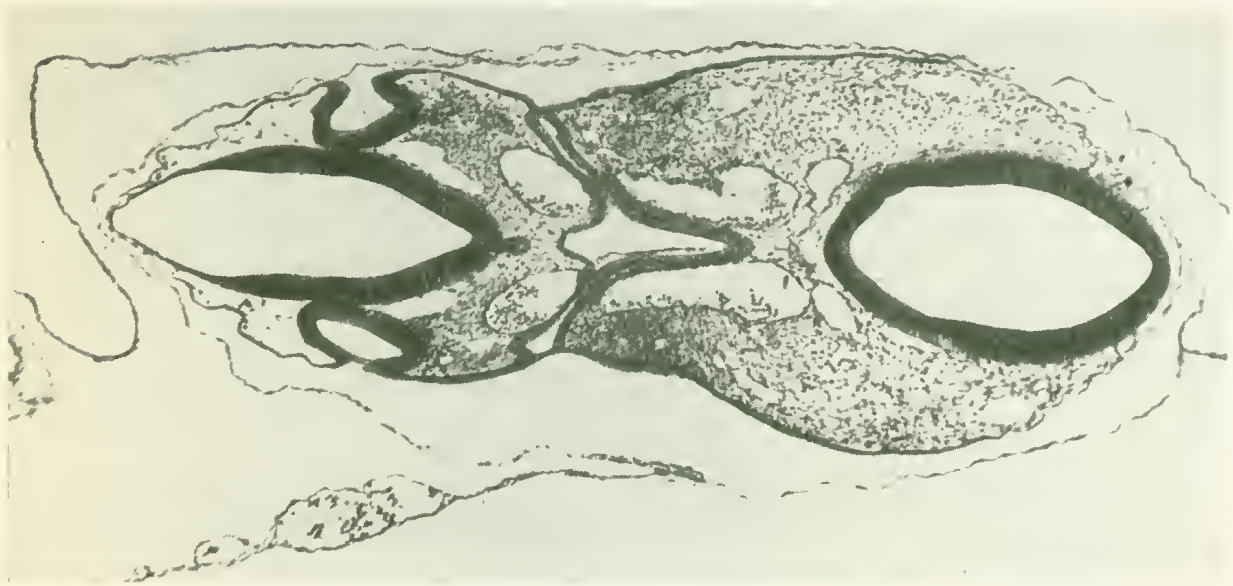
51. **Chick:** 21-somite stage, trunk region, T.S. *mag. 200×*



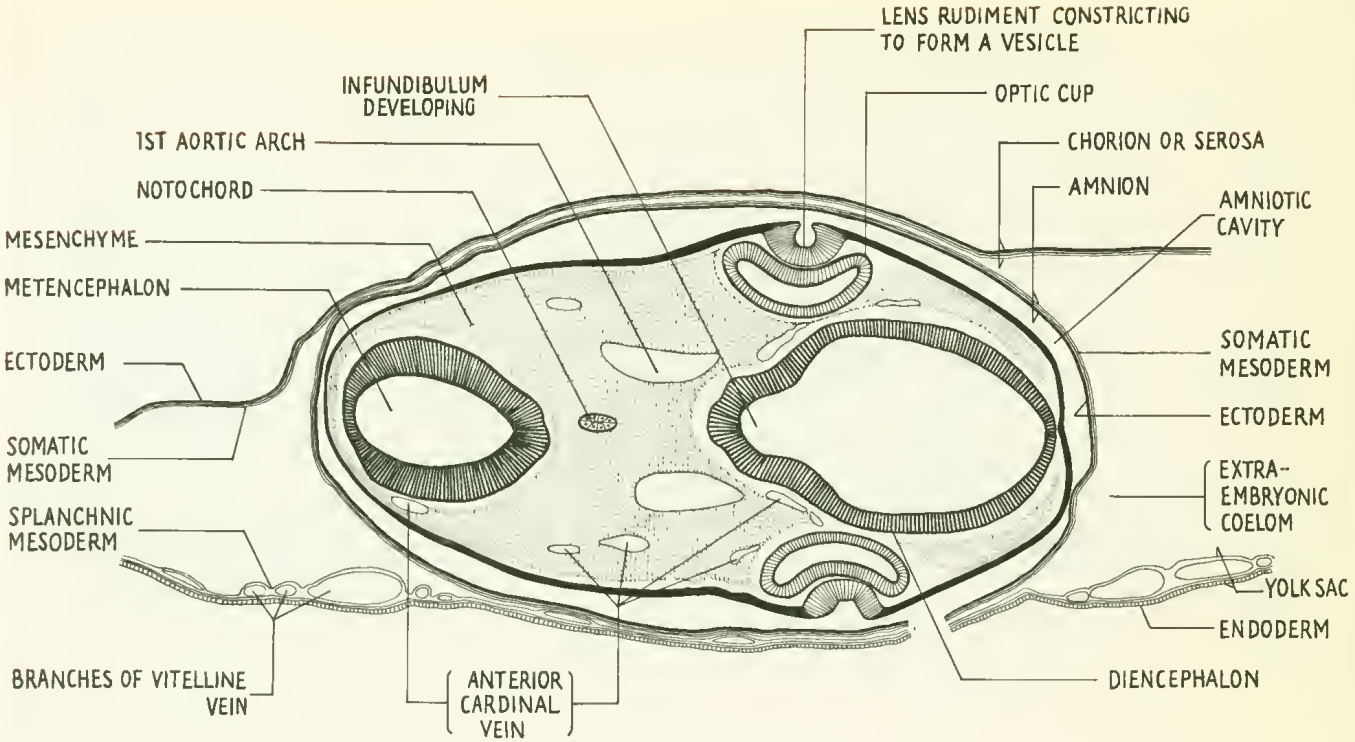
Drawing of specimen 51



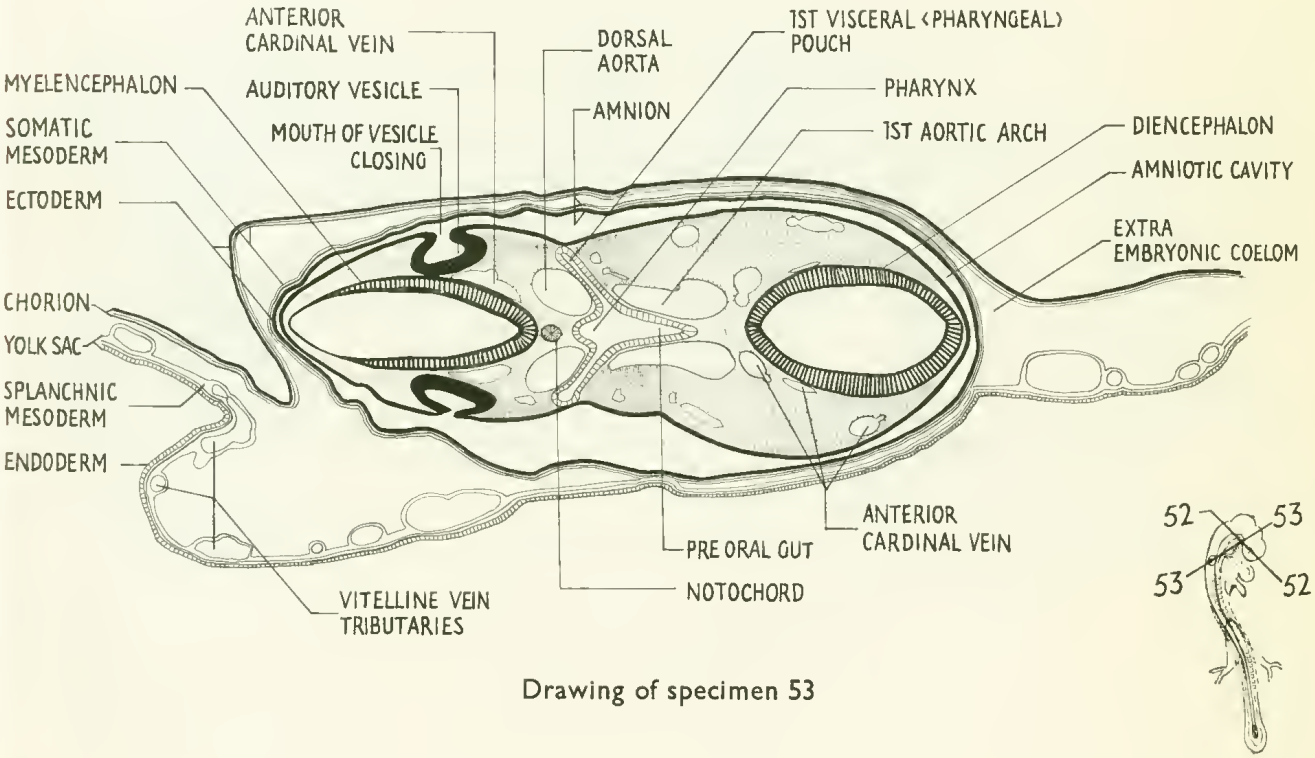
52. **Chick:** 24-somite stage, fore- and hind-brain, T.S. (1). *mag.* 45×



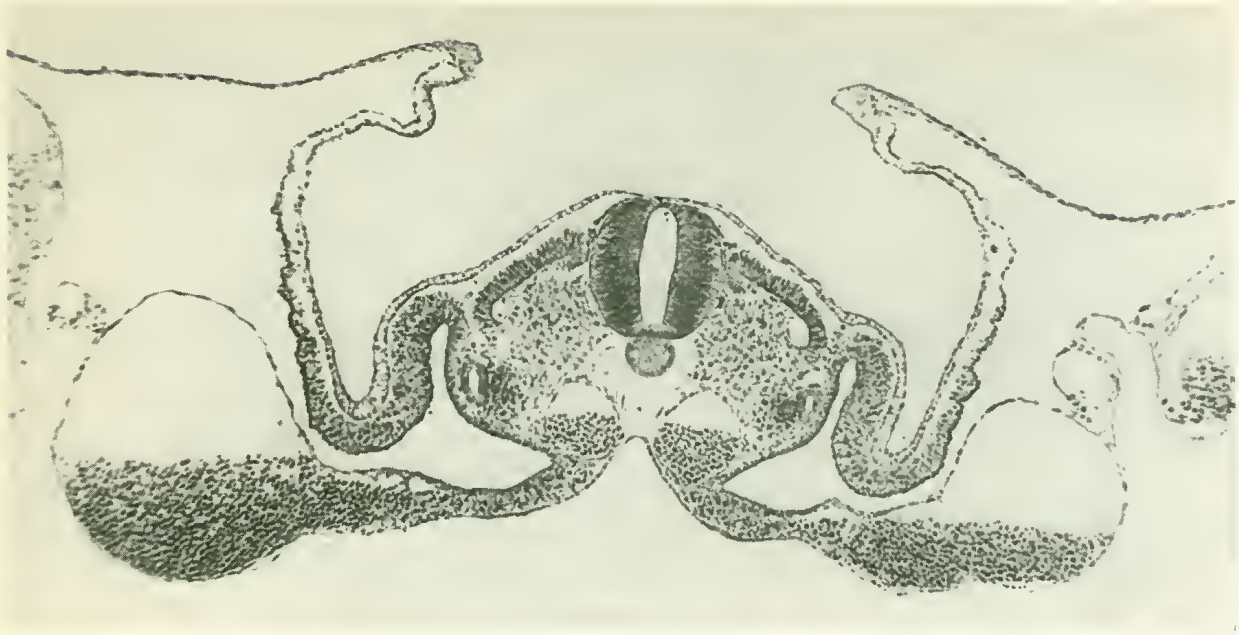
53. **Chick:** 24-somite stage, fore- and hind-brain, T.S. (2). *mag.* 70×



Drawing of specimen 52

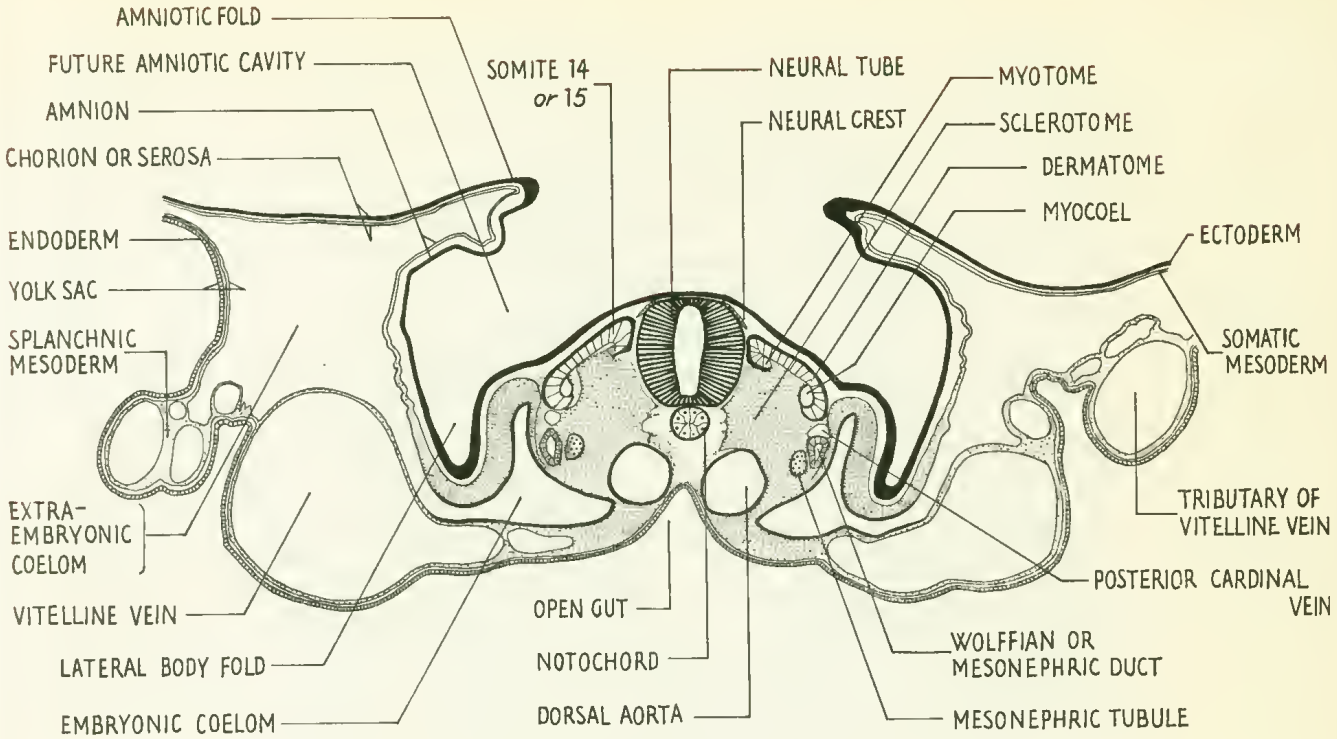


Drawing of specimen 53

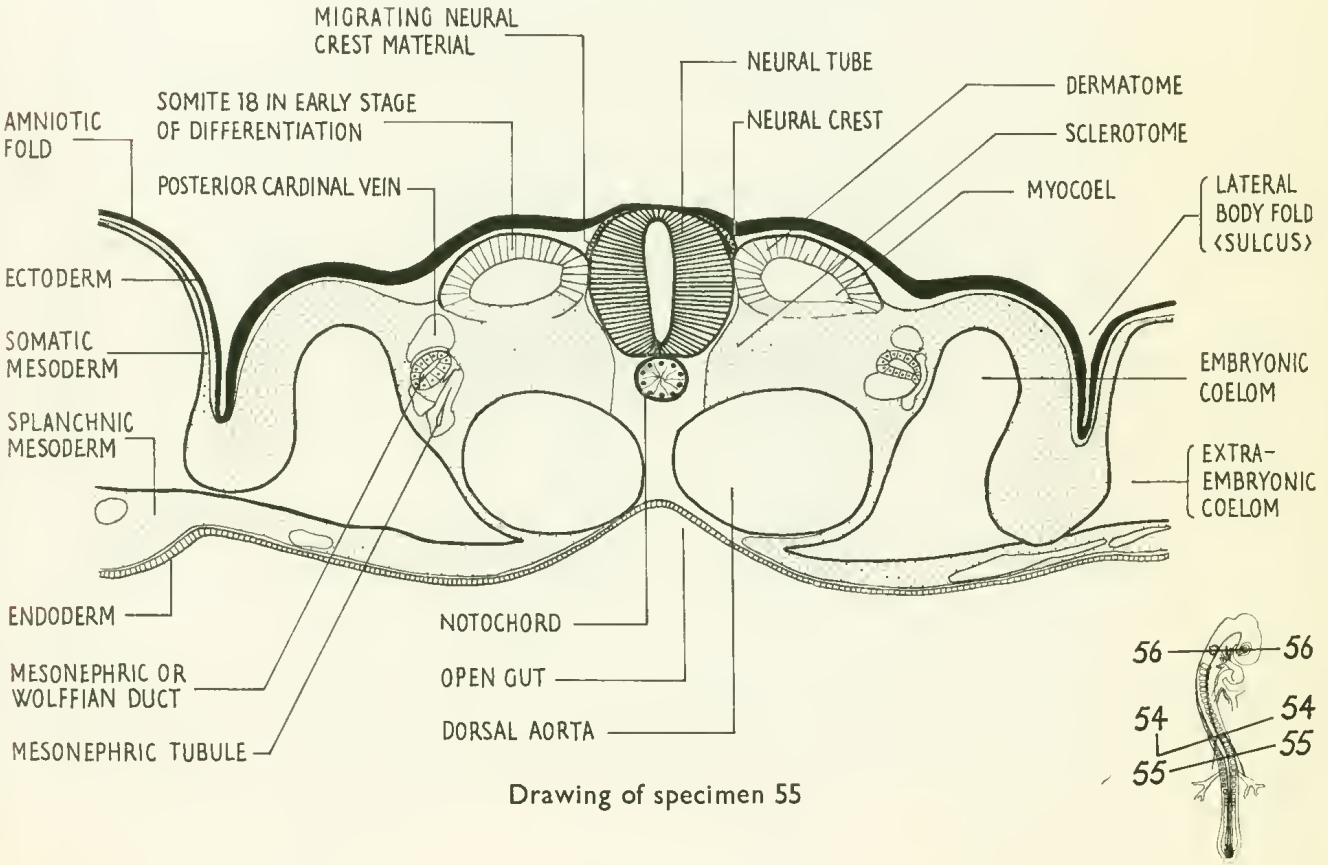


54. **Chick:** 27-somite stage, trunk region, T.S. *mag. 80*×

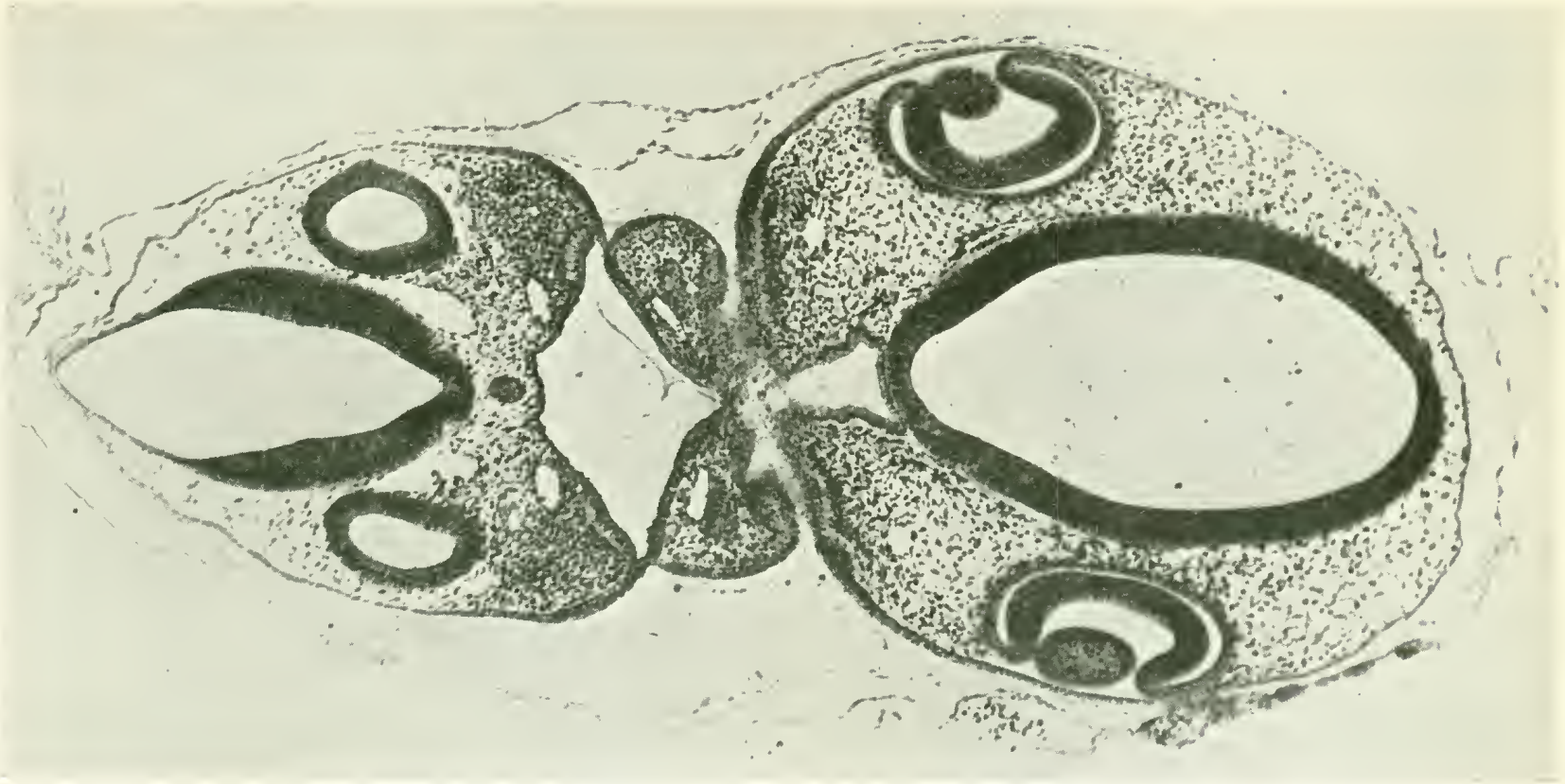
55. **Chick:** 27-somite stage, posterior trunk region, T.S. *mag. 95*×



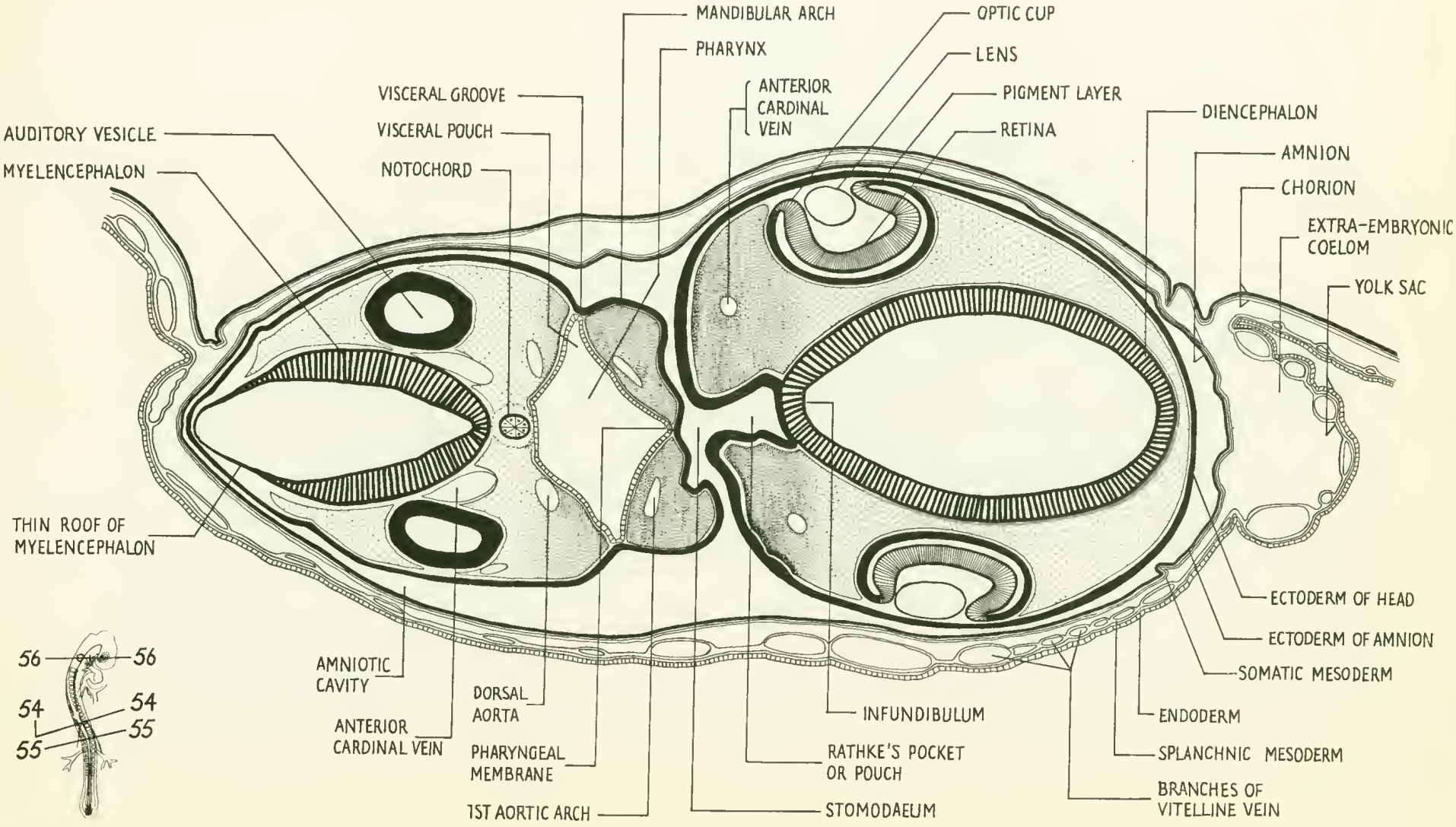
Drawing of specimen 54



Drawing of specimen 55

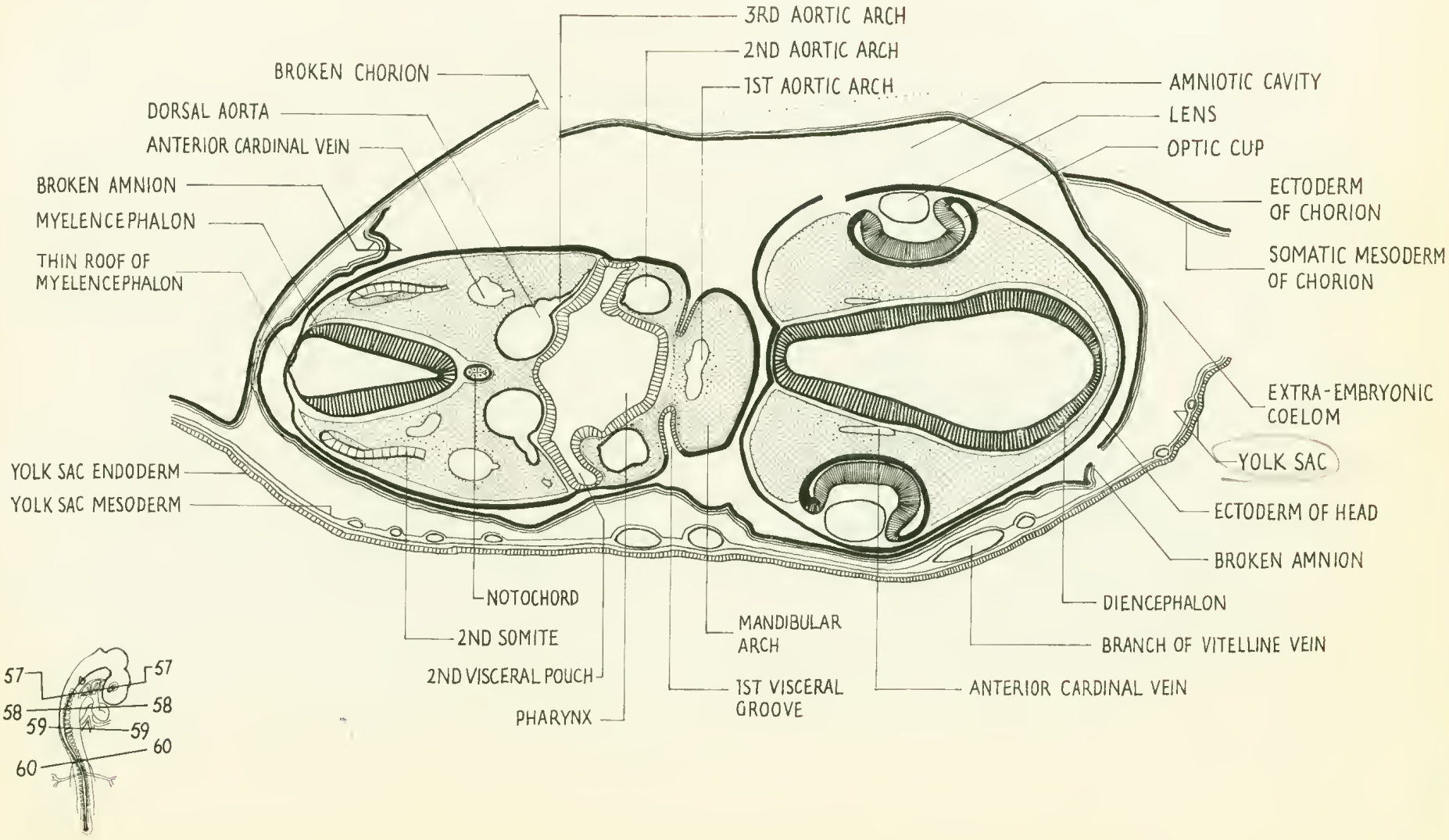


56. **Chick:** 27-somite stage, eye and ear region, T.S. *mag. 90*×

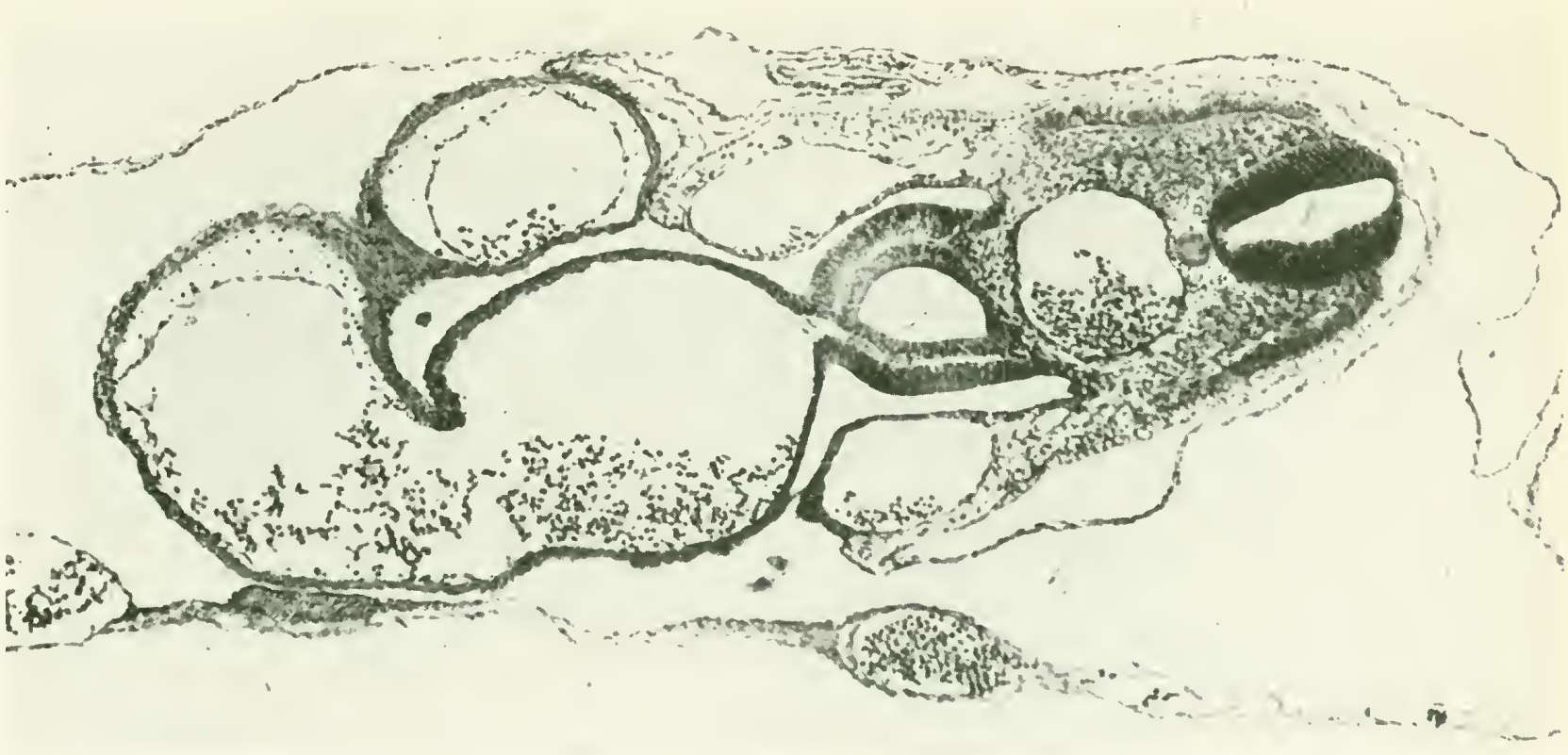


Drawing of specimen 56

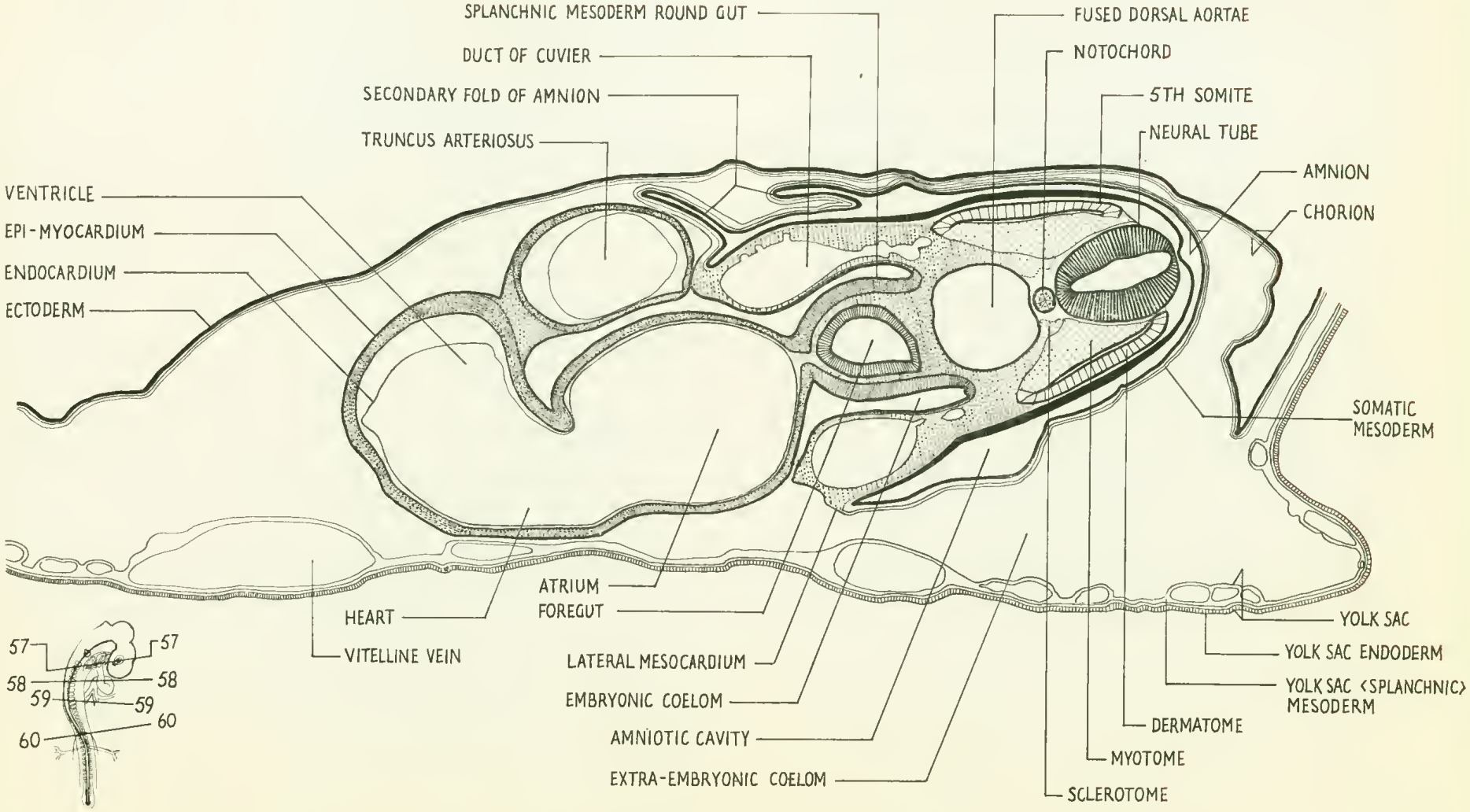
57. **Chick:** 30-somite stage, fore- and hind-brain, T.S. *mag.* 75×



Drawing of specimen 57

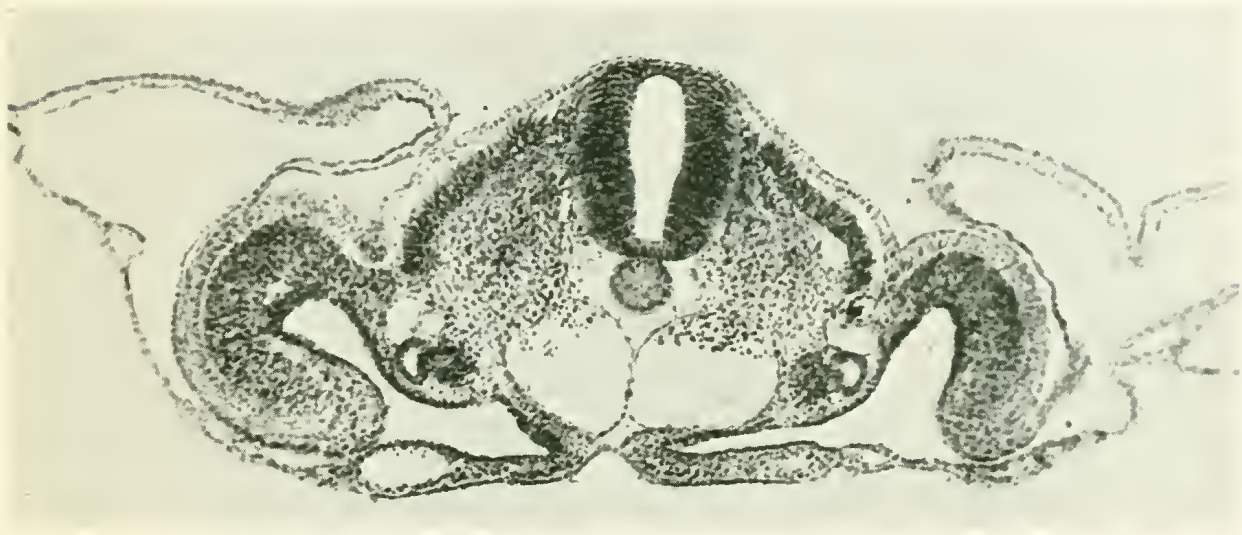


58. **Chick:** 30-somite stage, heart region, T.S. *mag. 130*×

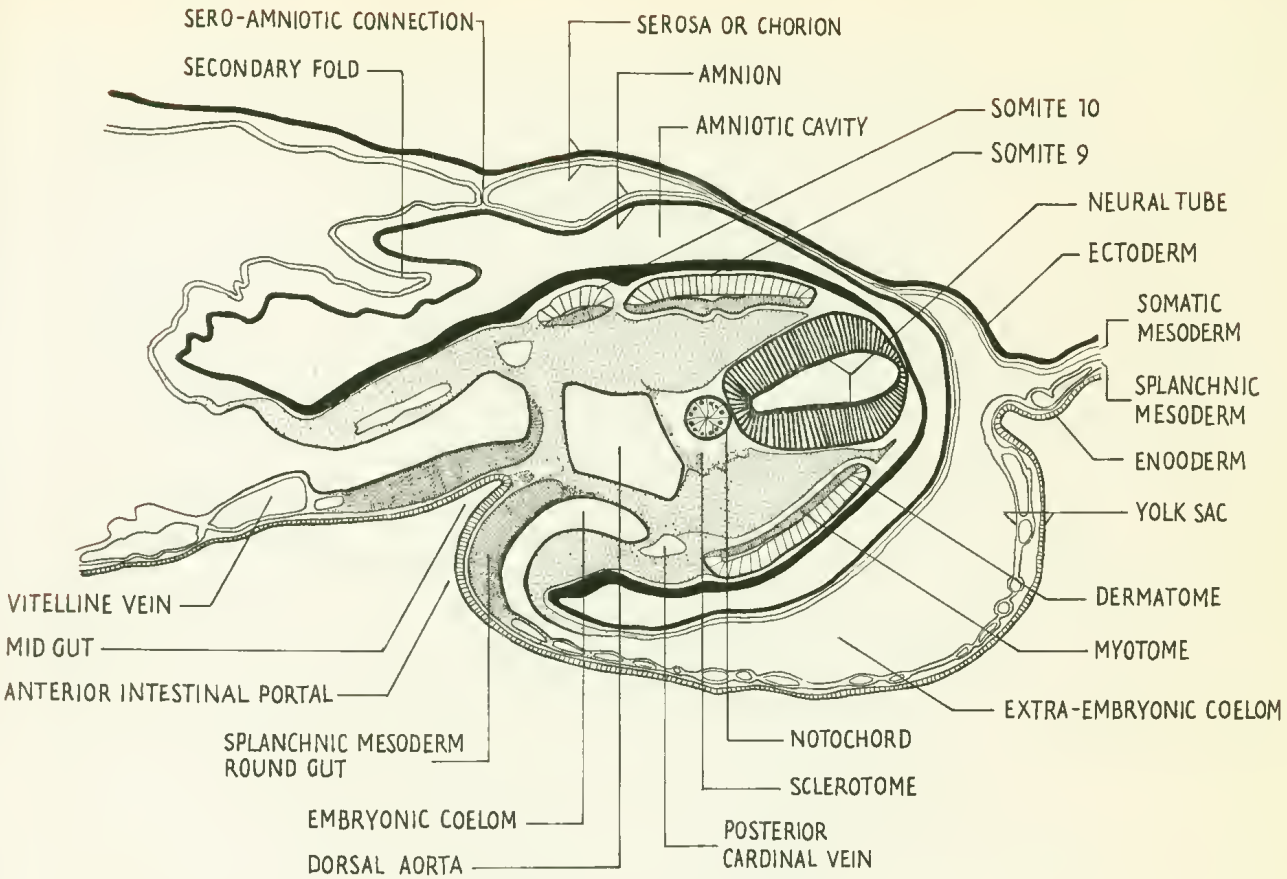


Drawing of specimen 58

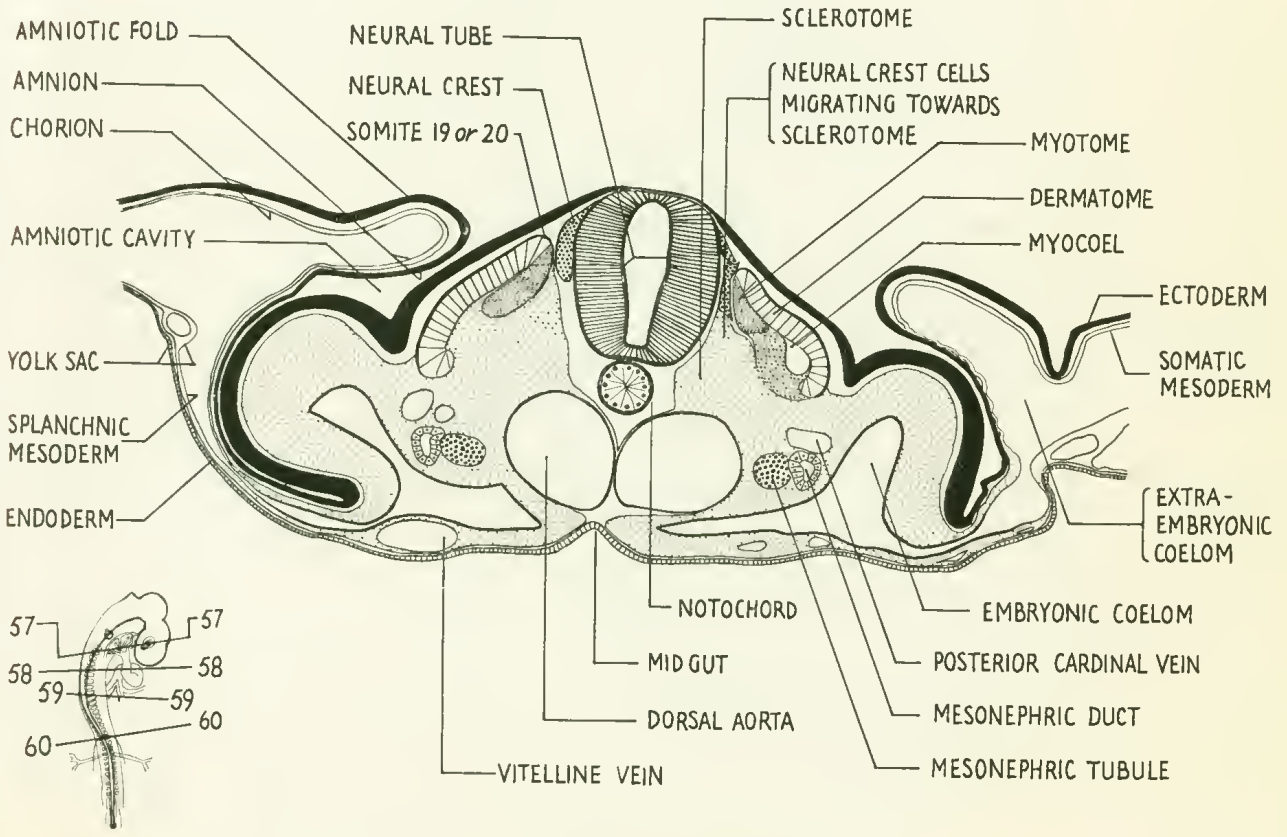
59. **Chick:** 30-somite stage, anterior trunk region, T.S. *mag. 125*×



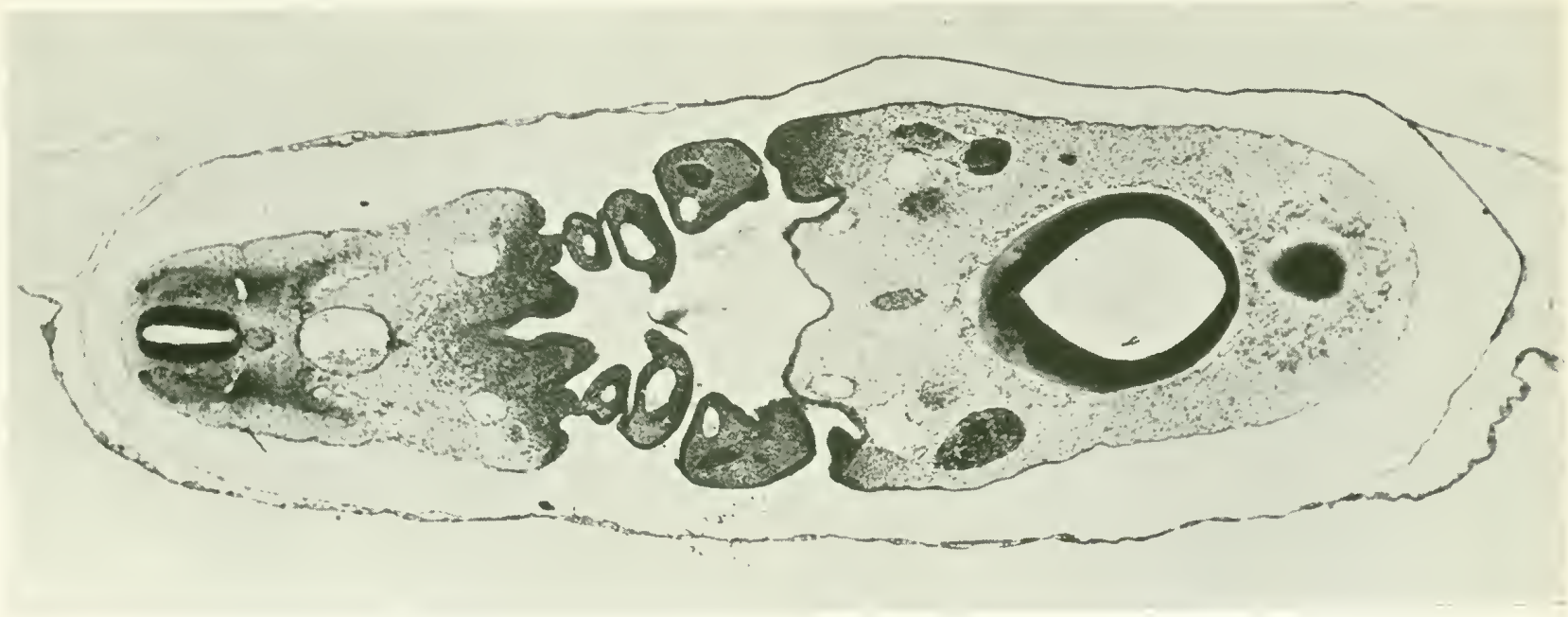
60. **Chick:** 30-somite stage, posterior trunk region, T.S. *mag. 85*×



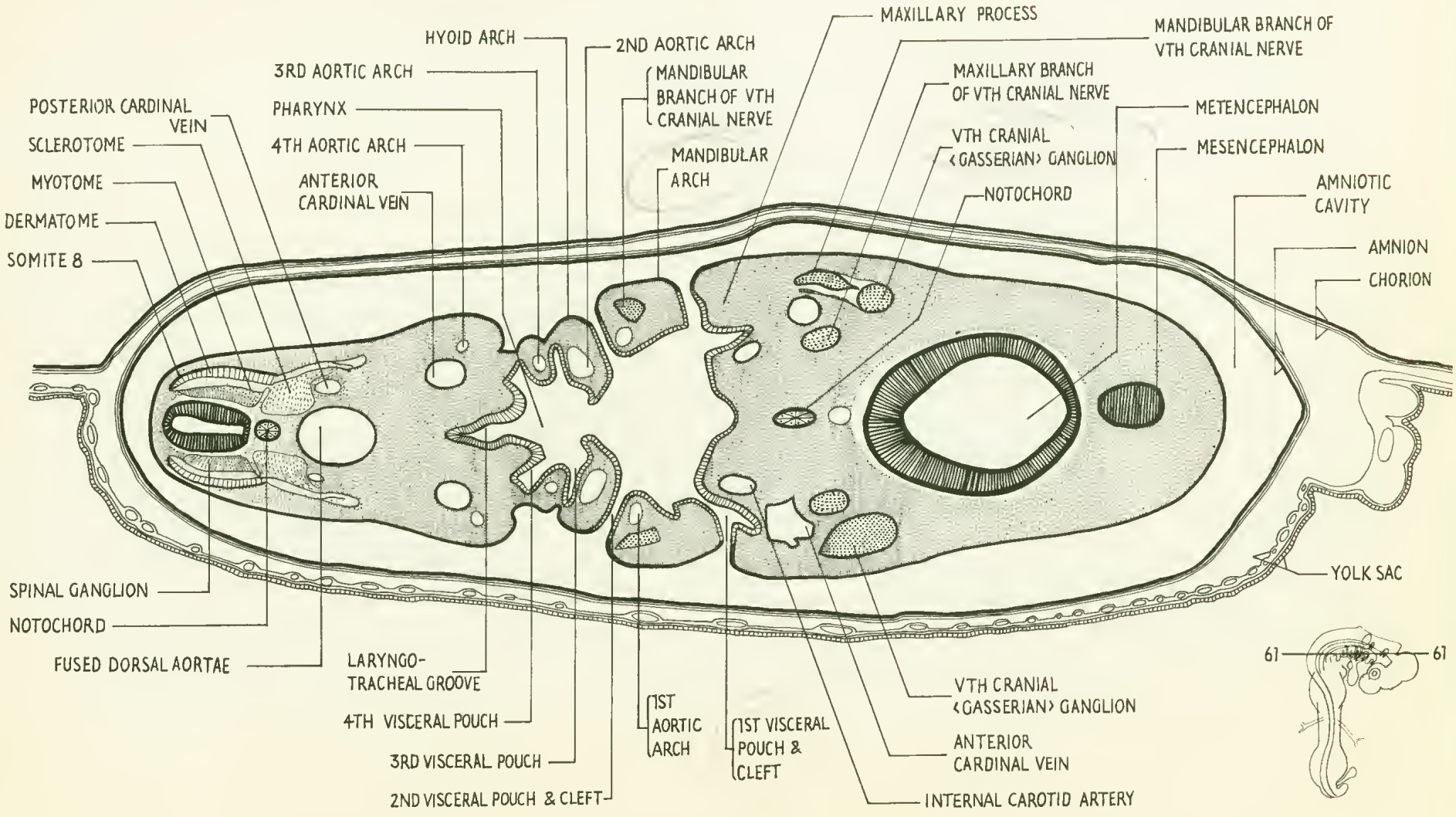
Drawing of specimen 59



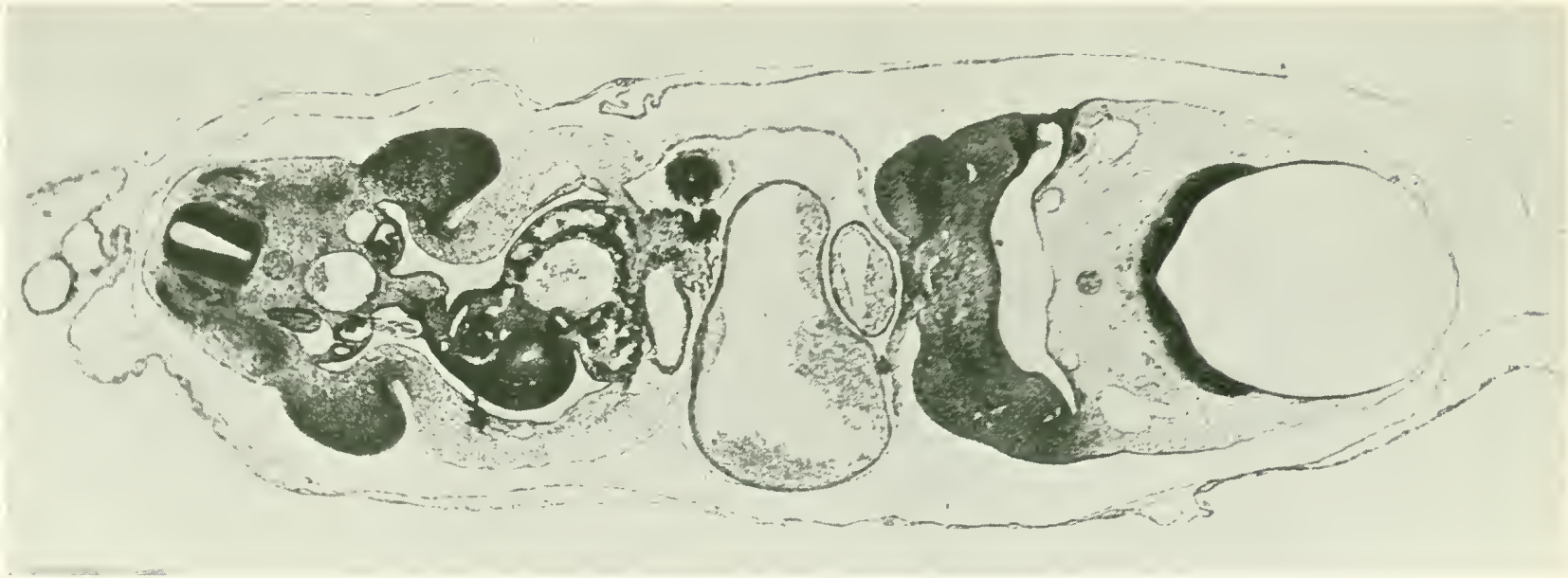
Drawing of specimen 60



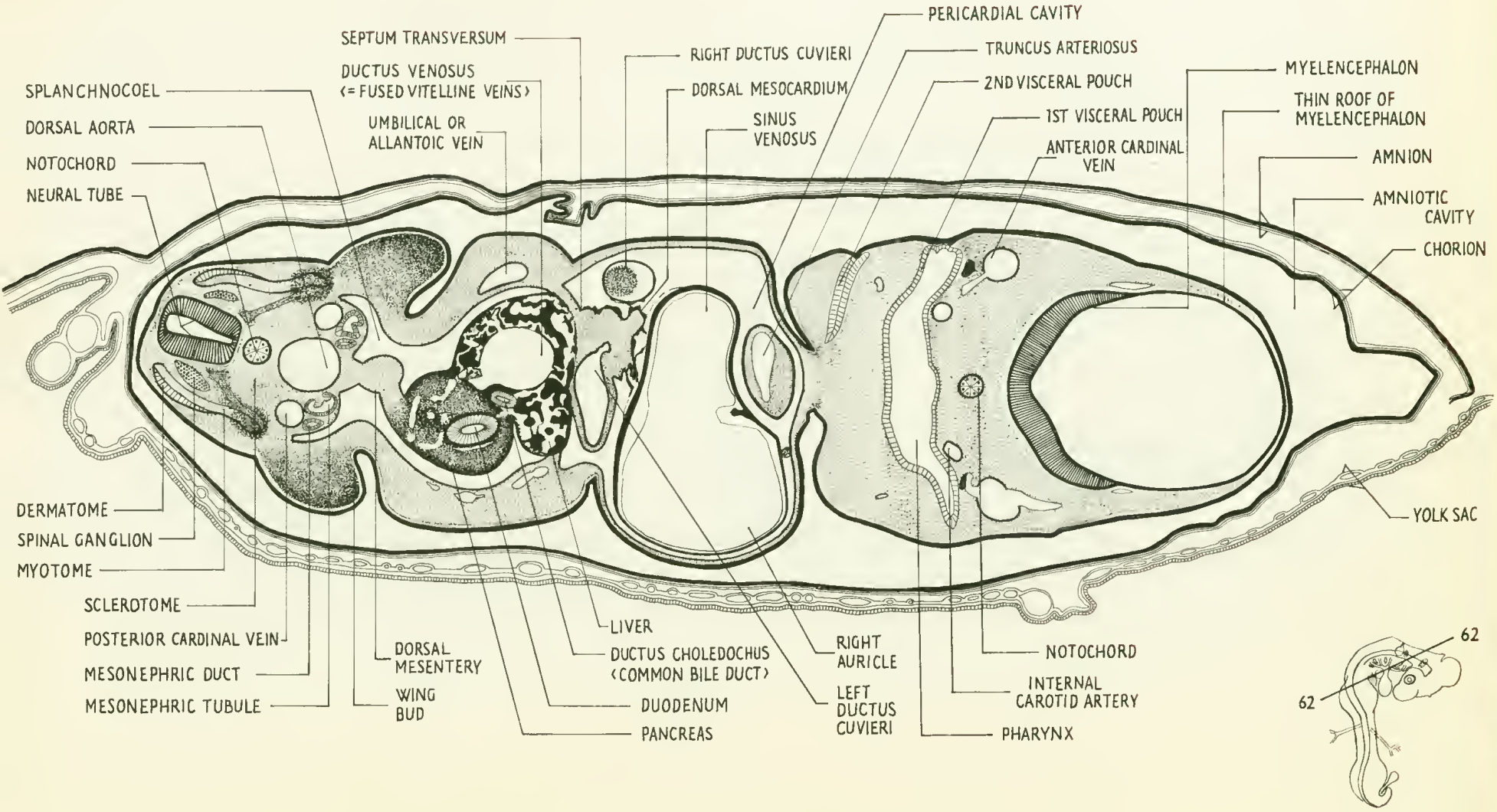
61. **Chick:** 36-somite stage, pharyngeal region, T.S. *mag.* 40×



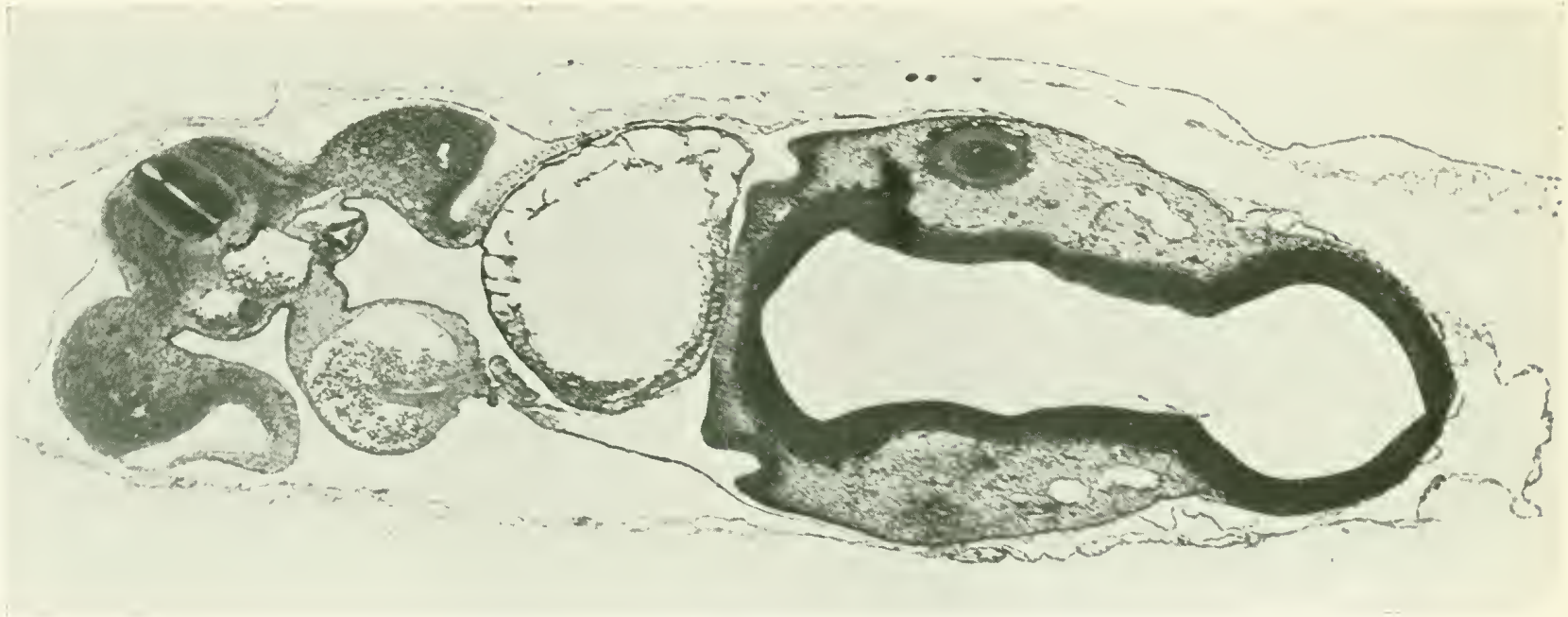
Drawing of specimen 61



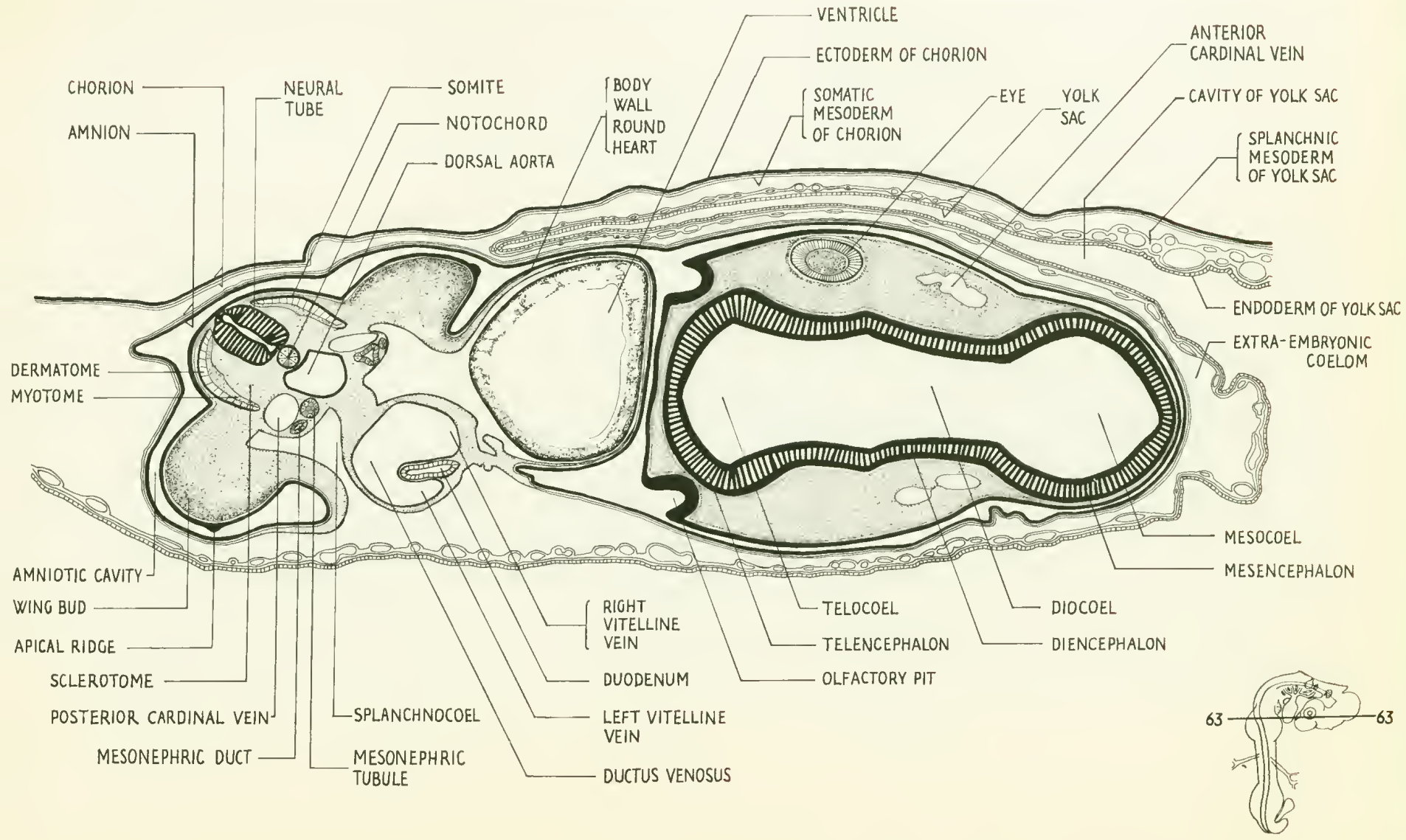
62. **Chick:** 36-somite stage, hind-brain region, T.S. *mag. 40*×



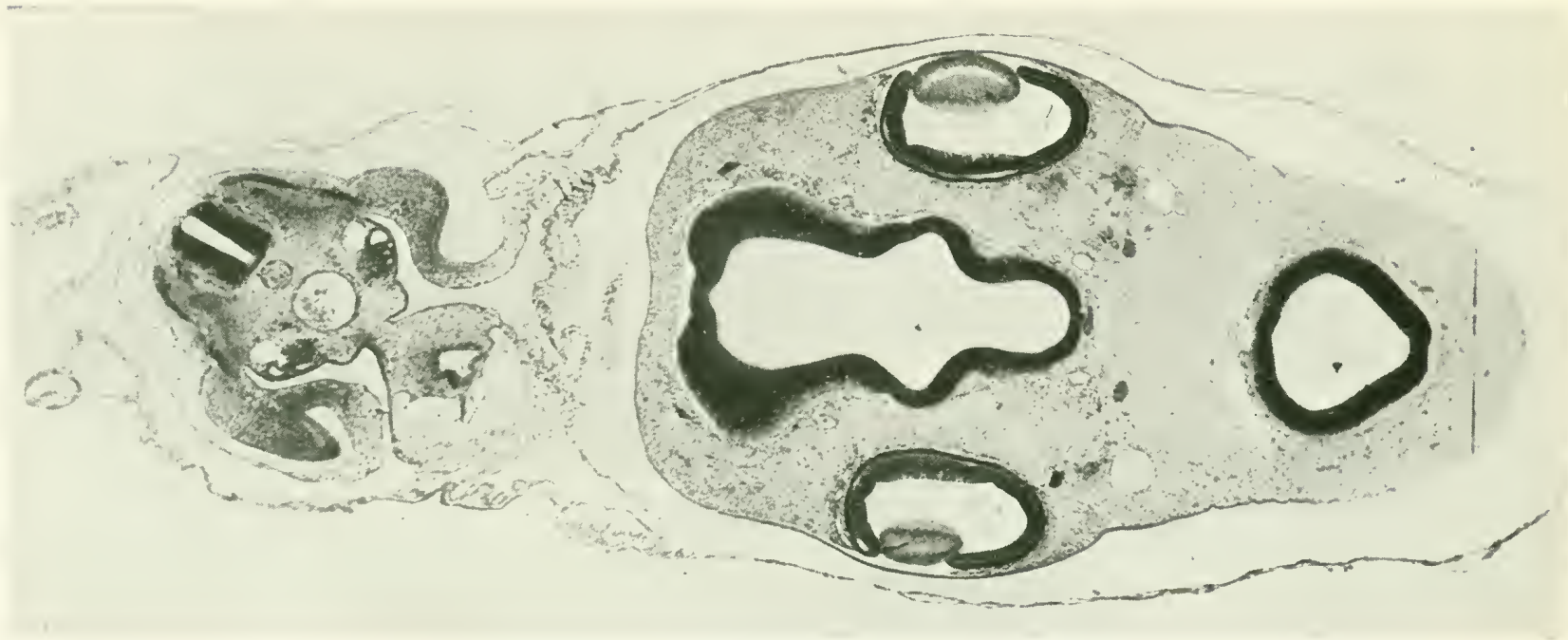
Drawing of specimen 62



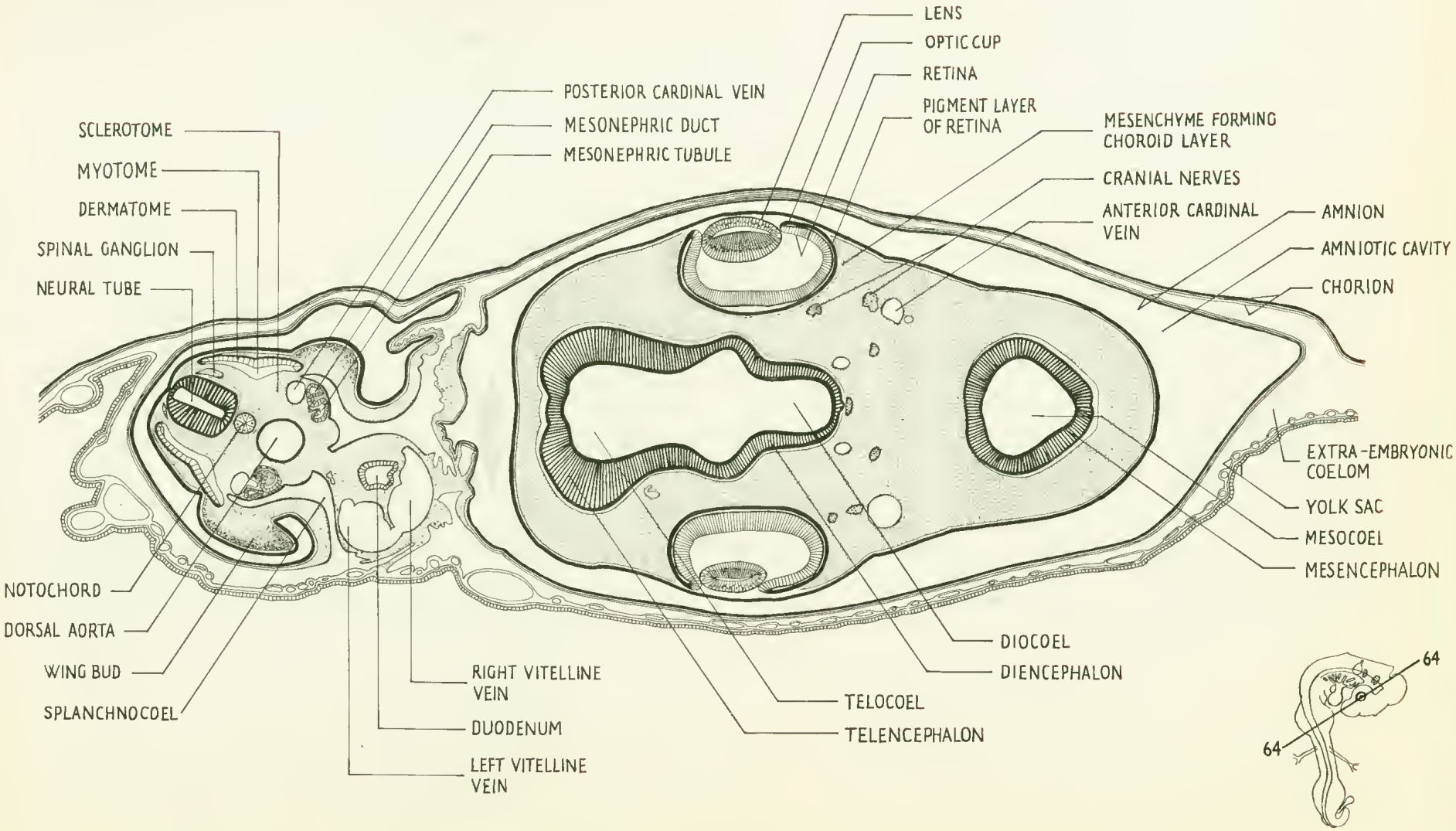
63. **Chick:** 36-somite stage, olfactory pit region, T.S. *mag.* 45×



Drawing of specimen 63

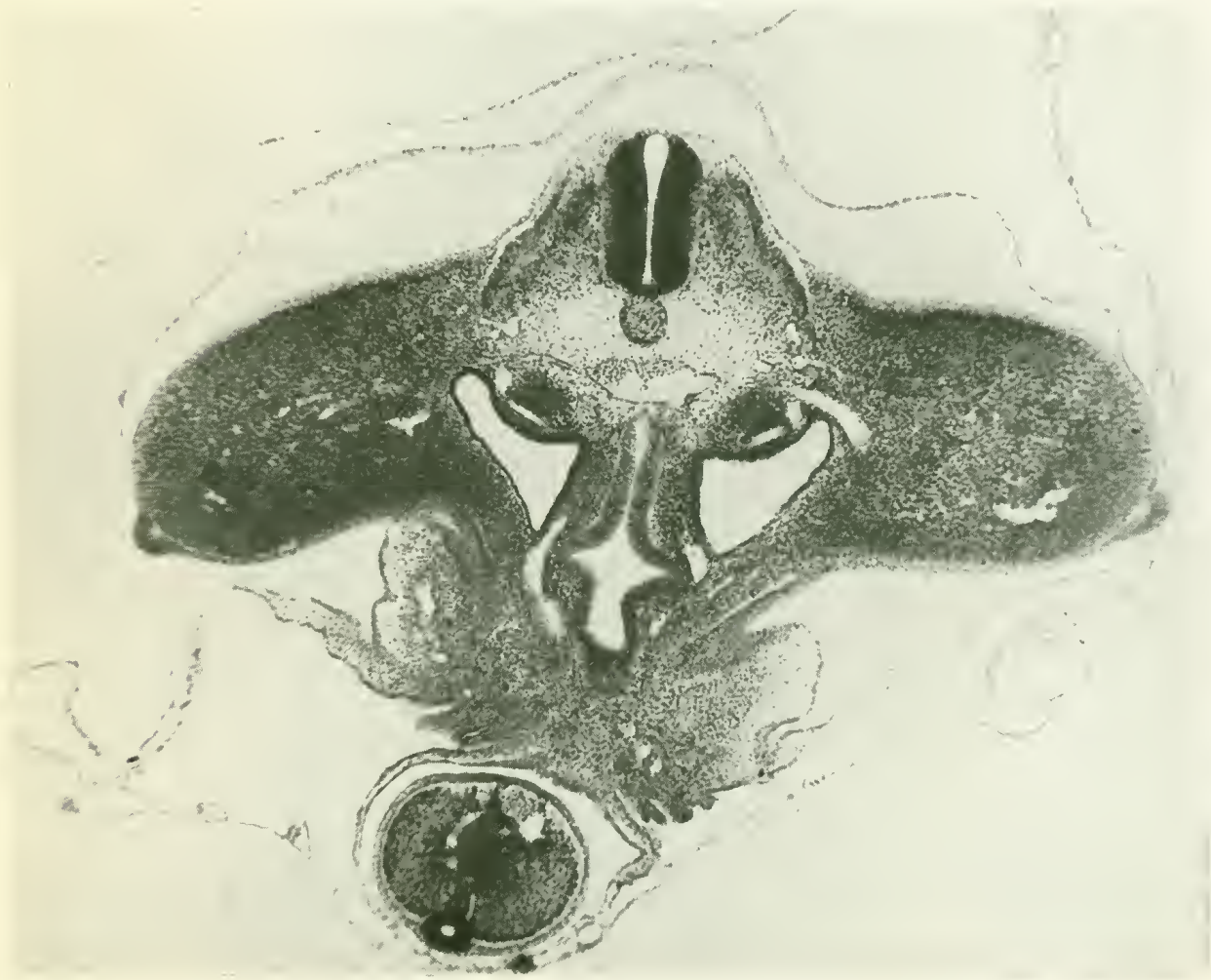


64. **Chick:** 36-somite stage, optic region, T.S. *mag. 40×*

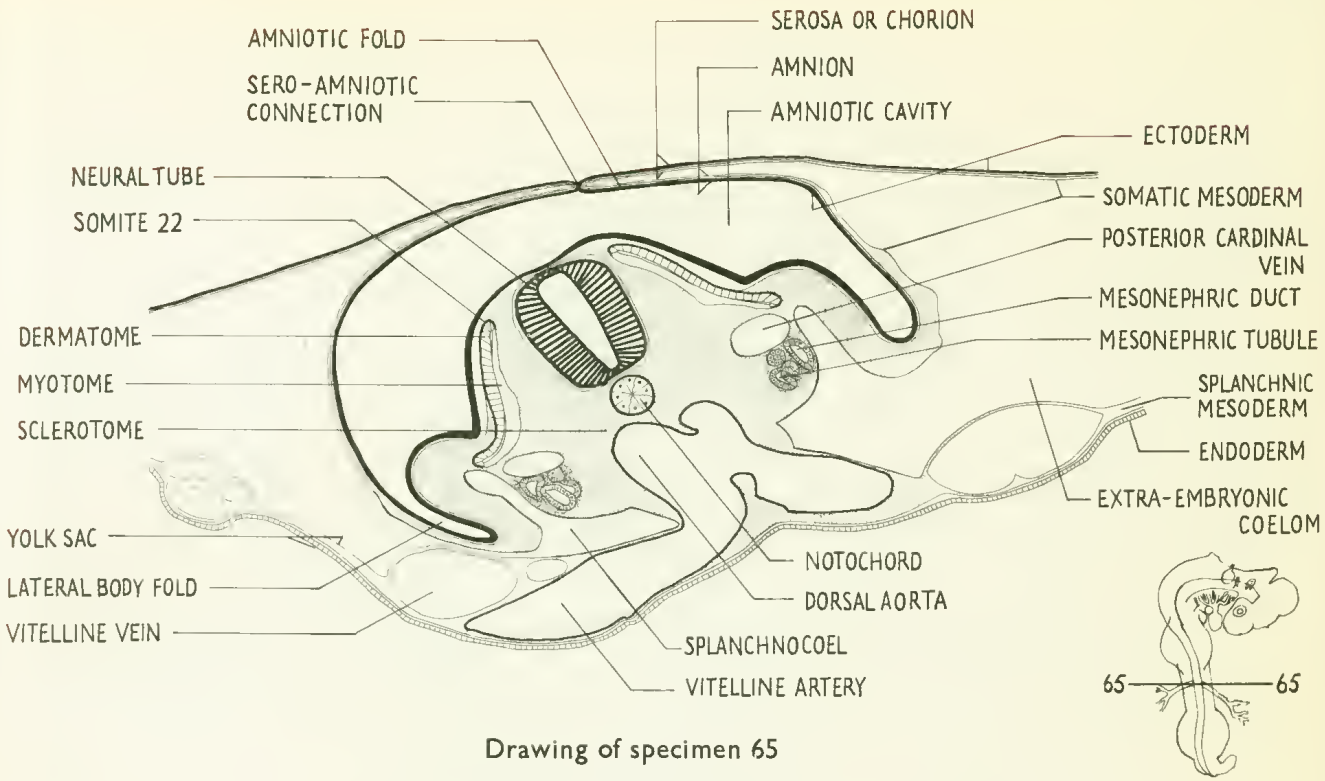


Drawing of specimen 64

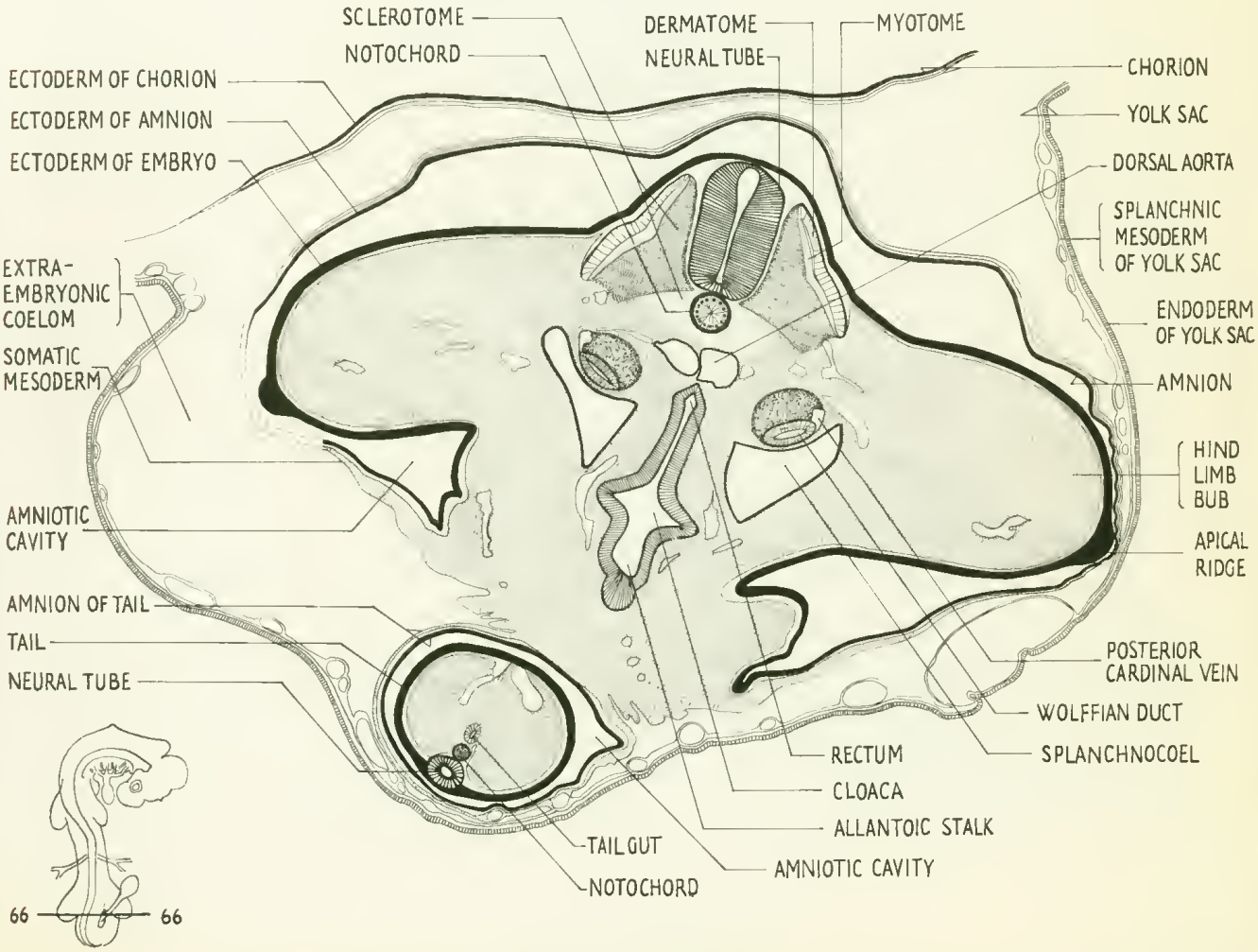
65. **Chick:** 36-somite stage, trunk region, T.S. *mag.* 75×



66. **Chick:** 45-somite stage, tail and hind-limb region, T.S. *mag.* 60×

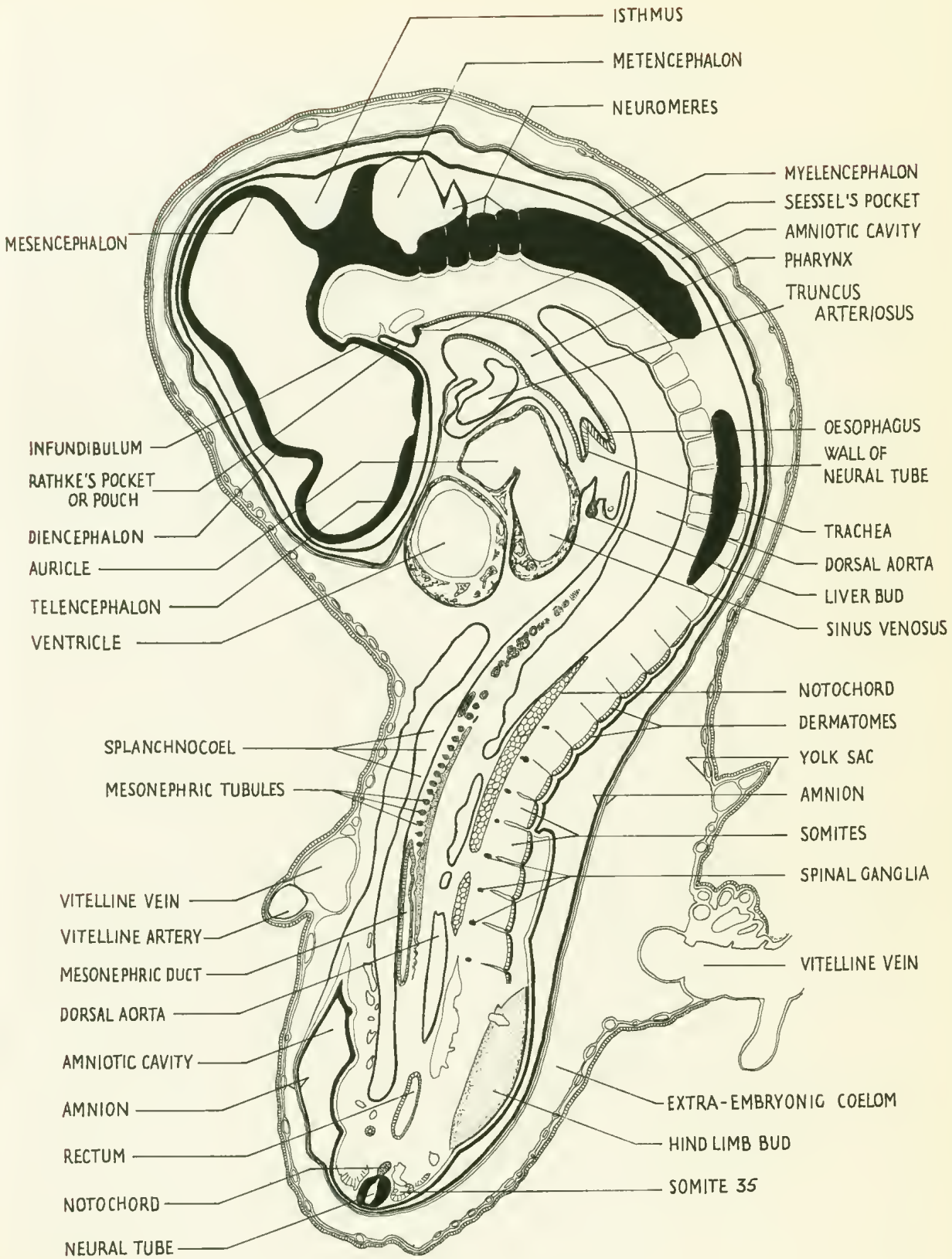


Drawing of specimen 65



Drawing of specimen 66

67. **Chick:**
36-somite stage,
H.L.S.
mag. 25×



Drawing of specimen 67

Number of somites	Stage*	Incubation time in hours according to:— Duval	Huettner	Patten	Lillie	Primitive streak	Nervous system	Mesoderm, somites and kidney	Vascular system	Anterior intestinal portal
0	4	20	17–18	18	18–19	Maximal length, 2.2 mm., i.e., 0.7 of area pellucida. Groove, pit and node present.		Shield shaped sheet of mesoderm spreads out laterally from the primitive streak.		
0	5 & 6	21	19	20	19–22	Begins to decrease in length, 1.9 mm. Notochord grows forward from node.	Neural plate and neural folds visible.	Lateral horns of mesoderm grow forward. The first somite may appear simultaneously with the formation of the head fold (stage 7).	Mesenchyme cells form isolated blood islands in extra-embryonic mesoderm.	First seen to be present.
3	8–	22	23	23	25–28	Reduced to a length of 1.5 mm.	Neural folds meet in brain region but do not fuse.	Lateral horns grow round the mesodermless proamnion. Segmented somites joined to lateral plate mesoderm by intermediate mesoderm (nephrotome). A cavity, the myocoel, appears in somites.	The blood islands begin to unite and the first blood corpuscles are produced within the resulting tubes.	Moves back as the foregut elongates.
5	8+	23–25	25	25–26	27–30	1.2 mm. long.	Fusion of folds begins in brain region; further back neural folds meet but they splay out over the somites.	The cells of the somites become radially arranged about the myocoel cavities; cavity reduced by a central core of cells. Lateral horns meet anteriorly.	The embryo becomes linked to the blood island system by vitelline veins. Paired primordia of the heart develop together with ventral and dorsal aortae.	Lies posterior to the heart primordia.
10	10	29–30	30	30–31	33–38	0.6 mm. long.	Except for anterior neuropore, fusion of folds is completed in the brain region. Three primary brain vesicles visible.	The intermediate mesoderm begins to separate off dorsally. The pronephric tubules develop from this material between somites six and ten. The first somite begins to disappear.	The heart primordia fuse to form a tubular heart which bends slightly to the right of the embryo. Faint and sporadic pulsation of the heart occurs.	May reach the first somite.
13	11	33–34	33	33–34	40–45	0.4 mm. long.	Five brain vesicles can be seen. Anterior neuropore closes. The neural folds fuse beyond the thirteenth samite.	The dorso-lateral buds differentiate into pronephric tubules and the pronephric duct forms by fusion of material from the tubules. First signs of Wolffian duct.	The heart becomes distinctly displaced to the right. The rate and amplitude of the heart beats increase. A network of blood vessels established in area vasculosa.	Reaches the second somite.
17	12+	37–41	37	38–40	46–50	0.2 mm. long.	Fore brain at an angle to hind brain due to flexure. A shallow infundibulum is present.	Connection between somites and nephrotomes is lost. The mesonephros develops along with pronephros below the somites. Wolffian duct extends from tenth to fifteenth somite. Differentiation begins in anterior somites.	The heart is beating efficiently by this stage and blood circulates. The heart is S-shaped. The first aortic arch begins to develop. The dorsal aortae fuse between somites three and four. The vitelline artery can be seen between somites sixteen and seventeen.	Reaches the third somite.
21	14+	43–46	43	44–48	48–52	No longer distinguishable, contributes material to tail bud.	Fore brain at right angles to hind brain. Fore brain enlarges in telencephalon region.	Pronephros begins to disappear anterior to the eleventh somite. In the anterior somites a distinct dermatome can be seen and cells migrate from the somites and neural crests to form the sclerotomes round the notochord.	The atrium begins to divide into right and left auricles. The first aortic arch is established and the second begins to form. Fusion of dorsal aortae may reach somite eight. The vitelline artery is distinct between somites 17–19.	Reaches the fourth somite.
24	15	44–46	48	48–50	50–55		The telencephalon becomes distinct from the diencephalon. Rathke's pocket grows under the infundibulum.	The posterior somites remain undifferentiated; anteriorly somites differentiate into dermatome, myotome and sclerotome. There are eleven pairs of mesonephric tubules between somite five and sixteen.	Besides the two auricles heart has distinct ventricle and conus arteriosus. Two aortic arches present. Dorsal aortae fuse as far back as somite twelve. The vitelline arteries lie between somites eighteen and twenty.	Is in the region of somites five to six.
27	16	48	50–52	50–55	51–56		Telencephalon and diencephalon become separated by the velum transversum. A distinct isthmus can be seen between the mesencephalon and metencephalon.	Differentiation into dermatome, myotome and sclerotome reaches somite twenty. Wolffian duct and mesonephric tubules seen in trunk sections.	The third aortic arch appears. The dorsal aortae fuse between somites four and fourteen. The vitelline artery lies between somites 19 and 21. Vitelline veins join to form ductus venosus which opens into sinus venosus.	Lies between somites seven and ten.
30	17	52	58–60	55–60	52–64		The isthmus deepens. Paired telencephalic vesicles develop. Roof of hind brain becomes very thin in myelencephalon region. Brain bent double by now.	Differentiation reaches the twenty-fifth somite. Wolffian duct grows back towards cloaca. Glomeruli can be seen in mesonephric tubules.	There are three complete aortic arches and the fourth begins to develop. The first pair of aortic arches may begin to atrophy at this stage. Dorsal aortae fused up to somite 16. Vitelline artery between somites 20 and 22.	Has moved back to lie between somites ten and twelve.
36	18+	68–72	72	72	72		The cerebral hemispheres develop from the telencephalic vesicles. The infundibulum joins with Rathke's pocket to form the pituitary.	Differentiation reaches the thirtieth somite. Wolffian duct reaches cloaca but may not fuse with it until later.	The first pair of aortic arches continue to atrophy as the fourth pair develop. Dorsal aortae fused as far back as somites 17–20. Vitelline artery is in region of somites 21–22.	Between somites thirteen and fourteen.

* Hamilton & Hamburger

Alimentary system	Eyes	Ears	Flexure	Torsion	Amnion	Allantois	Tail bud and limb buds
Foregut 0.15 mm. long.							
Foregut 0.3 to 0.4 mm. long.							
Foregut 0.5 to 0.8 mm. long.	*Primary optic vesicles form.*						
Foregut about 1.0 mm. long.	*Optic stalks begin to constrict at the base of the primary vesicles.*		*The head bends ventrally and sinks into the yolk.*				
Foregut is about 1.3 mm. long.	*Differentiated into optic stalk and optic vesicle.*	*The auditory placodes begin to form from thickened ectoderm.*	*This cranial flexure increases in the region of the mid-brain.*	*The first signs of torsion appear in the head region.*	*The head amniotic fold begins to rise up and grow back.*		
The foregut is 1.5 mm. long and there are indications of the first pair of visceral clefts.	*The ectoderm outside the primary vesicles thickens and becomes the rudiment of the lens.*	*The auditory placodes invaginate to form auditory pits.*	*Further sinking of the head into the yolk is prevented by the head twisting (torsion). Cranial flexure approaches 90°.*	*The head turns on to the left side. This torsion may reach the first two or three somites.*	*The head amniotic fold has grown back over the fore-brain.*		*The remains of the primitive streak begin contributing material posteriorly to the tail bud.*
The first pair of visceral clefts are distinct and the second pair begin to form.	*The lens rudiments invaginate to form lens vesicles. The optic vesicles invaginate to form optic cups*	*The mouth of each auditory pit begins to constrict and auditory vesicles form.*	*Cranial flexure, i.e. angle between fore- and hind-brain, is 90°. Cervical flexure begins in hind-brain region and trunk flexure can also be seen.*	*The head is fully turned to the left. The first five to seven somites also exhibit torsion.*	*The hind brain and first few somites are covered by the amnion. Tail folds may begin to develop.*		*There is a distinct tail bud.*
The first and second visceral clefts are clearly visible; the third pair begin to develop. The hind gut appears.	*The mouth of the lens vesicle begins to close.*	*The mouth of the auditory vesicle is reduced to a small aperture.*	*Cranial flexure causes the fore-brain to be directed backwards close to the heart. Cervical flexure becomes a broad curve.*	*Torsion is apparent in somites eight to ten.*	*The sero-amniotic connection is somewhat attenuated. The amnion covers somites six to thirteen. Tail fold appears.*		*The tail bud begins to develop posterior to the hind gut.*
The first, second and third visceral clefts are present. The liver bud appears as do the tail gut and anal plate.	*The lens becomes cut off from the ectoderm. The optic cups are almost closed. The retina distinct. The eye is still anterior to the ear.*	*The auditory vesicle is connected to the small ectodermal aperture by the ductus endolymphaticus.*	*Cranial flexure is at its maximum. Cervical flexure increases. Trunk flexure is noticeable in the region of somites ten to twelve.*	*Torsion extends to somites eleven, twelve and thirteen or even further.*	*The head fold grows back and may lie anywhere between somites ten and eighteen. The tail fold begins to grow forward.*		*The tail bud can be seen projecting behind the hind gut. The limb buds appear as low swellings.*
The fourth pair of visceral clefts develop. The liver bulge is now conspicuous. Tail gut extends further into tail. Cloaca begins to form.	*The optic cup closes. The eyes now lie posterior to the ears.*	*The aperture closes.*	*Cranial flexure remains unchanged. Cervical flexure is about 100°. Trunk flexure develops into a broad curve. Caudal flexure begins.*	*Torsion as far back as somites fifteen to nineteen.*	*The head fold has extended to the region between somites sixteen to twenty-four. The tail fold has grown forward over somites 29–30.*	*Begins as an outgrowth of the hind gut in the cloacal region.*	*The tail bud begins to curve forward. The fore limb bud lies between somites 17–19 and the hind limb bud between somites 26–30.*
Four pairs of visceral clefts. The tail gut begins to degenerate. The anterior and posterior intestinal portals approach each other, leaving an open intestinal umbilicus of 3 mm. Lung buds develop.	*The eyes, due to flexure, lie well posterior to the ears.*	*The auditory vesicle is pear-shaped with a narrow ductus endolymphaticus.*	*Caudal flexure causes tail to be at an angle of 90° to the body.*	*The whole posterior region exhibits some degree of torsion.*	*The head and tail folds meet or leave a small oval aperture over somites 26–28.*	*Allantoic stalk and vesicle. The vesicle enlarges after 72 hours.*	*Limb buds are now quite conspicuous and begin to exhibit nipple-shaped apices. The hind limb bud extends to somite 32.*

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